South pacific underwater medicine society

C O N T E N T S

1. Editorial Page 5

2. In Support of Emergency Ascent Training
   Dennis K Graver 7

3. A New Approach to Out of Air Ascents
   GD Harper, MC 14

4. The Ambulance in the Valley
   Anon 18

5. A Sea Wasp Attack in Western Australia 19

6. An Incident During Pool Training
   David McIvor, PhD, BSc (Hons) 21

7. A Diving Incident 23

8. Provisional Report on Australian Diving Deaths in 1977
   Douglas Walker, MD 25

9. The Immediate Management of Thermally Unbalanced Casualties in the Field
   David A Youngblood, MD, MPh, TM 28

10. Water Inhalation Accidents
    RV Trubuhovich, MD 45

11. World Life Saving Medical Advisory Panel Meeting - Newport Beach
    Ian Mackie, MD 53

12. Workshop on the Treatment of Decompression Sickness
    LCDR KM Green, MC USN 58

13. Pathological Investigation of a Fatal Diving Accident
    Ian M Calder, MD 64

14. Diving in the North Sea during 1977 Situation Report
    Cmdr SA Warner, MBE, DSC 65

15. Diving Safety Memoranda No. 18, 1978
    Cmdr SA Warner, MBE, DSC 69

16. Responsibility of a Diving Supervisor
    Cmdr SA Warner, MBE, DSC 70

17. SPUMS Scientific Conference - SUVA - June 1978

    i) Thermal Problems of Diving
       Glen Egstrom 71

    ii) Diving Safety
        Glen Egstrom 73

Contents continued .... Page

iii) Drowning
Darryl Wallner 73

iv) Diver Performance
Glen Egstrom 74

v) Salvage Diving
Ian Lockley 75

vi) Barotrauma
Ian Unsworth 75

vii) ENT Problems of Diving
Bill Hurst 76

viii) Physiology of Immersion
Glen Egstrom 76

ix) New Toys
Glen Egstrom 77

x) Dysbaric Osteonecrosis
John Knight 78

xi) Physiology of Diving Mammals
John Knight 79

xii) Clinical Decompression Sickness
John Knight 80

18. Exercise and the Heart: is "Norm" right? 82

19. Minutes of the AGM of SPUMS 83

20. Physiological Concerns of Women Divers
Susan Bangasser 84

21. Health and Safety Executive - Recommendations on
Medical Examination of Divers 88

22. Comparative Respiratory Physiology of Diving in Man and Dolphin
Deneice L Van Hook 94

23. Diver Respiration Problems 95

24. Can it Happen to you?
Ron Pavelka 99

25. Service Page 101

S.P.U.M.S. JOURNAL
JULY - DECEMBER 1978

Printer: F & P Blackwood. PO Box 64, Panania. 77-7456

SUBSCRIPTIONS

Members pay $20.00 yearly and Associate members $15.00. Associate membership is available for those neither medically qualified nor engaged in hyperbaric or underwater related research. Anyone with an interest in joining should write to Dr John Knight, Secretary of SPUMS, 80 Wellington Parade, East Melbourne, Victoria 3002. Membership entitles attendance at meetings and the annual Conference, and receipt of the Journal/Newsletter.

Treasurer: Dr W Rehfisch, 5 Allawah Avenue, Frankston VIC 3199

NOTES TO CORRESPONDENTS AND AUTHORS

Please type all correspondence 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 same in a presentation suitable for photo-reproduction direct. Books, journals, notices of Symposia, etc will be given consideration for notice in this journal.

REPRINTING OF ARTICLES: Permission to reprint articles from this journal will be granted on application to the Editor in the case of original contributions. Papers that are here reprinted from another (stated) source require direct application to the original publisher, this being the condition of their use in this Journal.

Address correspondence to:

Dr Douglas Walker
PO Box 120
NARRABEEN NSW 2101

DISCLAIMER

All opinions expressed are given in good faith and in all cases represent the views of the writer and not necessarily representative of the policy of SPUMS.

EDITORIAL

Alexander the Great is credited with expressing frustration when faced with the fact that there were no fresh worlds left for him to conquer. Had he lived nowadays his interest in venturing underwater could well have led him to join our Society and so to realise his ambition to continue for ever to encounter the intellectually taxing and exciting, for the greater our knowledge of hyperbaric and diving medicine the fewer become our certainties. The self-evident teachings of today become the gently scorned dogmas of yesteryear at an alarming pace as human complexity and variability become better recognised by doctors. Nowadays only a newly trained diver is really certain about decompression sickness! But if the first step towards knowledge is the awareness of ignorance, at least we are now started towards a better understanding of our problems and how to best circumvent them. In a modest way the papers printed in the Journal seek to speed this process of stimulating fresh thought on the wide, if not quite infinite, range of problems now suspected to exist. What a tragedy if some engineer should invent an “Everyman” 1ATA suit and destroy all the interest in Diving Medicine!

The papers by Graver and Harpur in this issue conclude the basis-for-discussion on Emergency Action by divers. They should be read in conjunction with those in the previous issue and with a little more than a quick glance at the poem, an anonymous effort recently printed in the Aviation Safety Digest. As one can only guard against predictable dangers, and as experience is the best indicator of problem areas, reports of actual incidents are the essential ore from which one may extract theories of causation and rules of correct conduct. It is therefore with real pleasure that several papers relating to incidents are published. That the conclusions one draws may be equivocal rather than satisfyingly clear adds to their value, for that is the way medicine really is. Too often cases illustrate the conclusion rather than ventilate the uncertainties of the reality, a failing similar to that of the early painters who drew the Australian Bush as if it were Europe with sunshine. It is hoped that other readers will now set their cases on record: confidentiality for sensitive facts is easy to ensure. Of course it is not only fatalities that have lessons for those willing to learn; those who survive can naturally provide more accurate information than can the dead! Though a conscientious Coroner can improve on even the statements Police obtain in cases with a fatal outcome, he cannot ask the victim to explain doubtful points.

It is generally accepted nowadays that few problems progress inexorably badly unless a succession of negative factors are operating. A single isolated mistake rarely kills. To be of real value reports must be committed to a permanent form, verbal reminiscences having too restricted and fallible a circulation to maximise their value. The central confidentila collection of reports, as now being practiced in the UK (and on a rather more modest scale by Project Stickybeak here in Australia), can and does show trends not readily apparent when reports are read as isolated events. The UK Department of Energy and the AODC schemes, which will be the subject of note in later publications of the Journal, give the lie to the belief that reporting schemes cannot be set up by those involved in Commercial Diving because of business rivalries and legal liability should too much truth be stated. The Editor, as always, will be pleased to receive confidential reports (as well as those intended for publication) on any matter relating to diving. Knowledge sharing saves lives. And a brilliant example of the value of full reporting is the paper by Dr David Youngblood. Permission to reprint this is much appreciated. The intrusion of doctors into the practical word of divers’ must be tempered at all times by a willingness to listen to unorthodox views and to consider the possibility that they may be, at least in part, correct. Most divers have still not realised that doctors have lost their somewhat selfrighteous certainties and need incident reports as a check on accepted beliefs: dogma closes eyes and ears and inhibits reporting of the unusual.

Nevertheless accidents will happen, and for divers this will often result in hypoxia or drowning risk. The papers by Doctors Trubohovich and Mackie indicate the thought being given to resuscitation should such problems arise, while Commander Greene has prepared the report on a Workshop discussion of Decompression Sickness. DCS seems to be a problem that increases in complexity the more it is investigated. Hopefully Dr Calder's advice will rarely be required by our readers. Commander Warner's reports once more grace our pages, to our gain. The work he and others undertake to improve the safety of the off-shore diving industry will have as a spin-off improved diving procedures for all types of diving around the world.

This year we have resumes of most of the papers given at the SPUMS Scientific Conference, though those who were unable to attend must remain in ignorance of the informative Workshop discussions. We are in debt to Dr Knight for the preparation of these reports.

In these days of "Women's Lib" it is sometimes necessary to remember that "equal" and "identical" are not synonyms. As doctors we may admit to some awareness of this, at least in theory, though in practice the physiological differences tend to be forgotten. Such has been the case till recently in the field of Diving Medicine. There have been guesses in plenty but facts in scarcity till women divers started to investigate for themselves. The liberation of thought that has resulted will in time spread back to make inconstant, response to the stresses of diving. When that occurs, divers will regard rules as important guides to survival rather than "laws" that a smart fellow can bend a little if nobody is watching. The significance of the menstrual cycle, the pill, and pregnancy can only be defined by research such as that of Susan Bangasser and others in the USA. By a strange twist of fate a "sexist" Italian law prohibiting women technicians in hyperbaric chambers may have an unexpected seal of approval awarded in time.

The attitude to medical fitness for diving is still a matter requiring greater thought than it presently receives, if only to decide who is to be protected from what. The UK intention to restrict the power to issue such certification of professional divers to doctors who have received at least a basic course of instruction in diving medicine, which is not necessarily RN Medical Officer diving medicine, is both logical and timely. But the suggestion in the USA that even the slightest degree of spondylolisthesis is to be an absolute bar to employment (Pressure, August 1978) is an example of the absurd posture that results if absolute initial physical perfection is assumed by Courts of Law, with the corollary that any deterioration is the "fault" of someone else. This is a step back to primitive life where the witch doctor was called in to cast out spells and discover the enemy responsible for every illness. Unless this trend is halted nobody in their right mind will use divers at all in a short time: machines are so much easier to standardise. Man has evolved by being imperfectly adapted to his environment in some degree, so able to survive change. It is hoped that the matter receives thought and comment.

Our Society has members and correspondents in all Continents. To all we send our Seasonal Greetings for Christmas and the coming New Year, the time of good resolutions. It is suggested that you make 1979 a time for recording and reporting all types of incidents relating to diving and hyperbaric exposures. As Mr Peter Harrigan our cartoonist shows, making a different point, great things are expected from our readers. Please produce the goods!

IN SUPPORT OF EMERGENCY ASCENT TRAINING

Dennis K Graver

Significant controversy currently exists regarding Emergency Ascent training. Such training for sport divers is advocated and arguments in favour of the training not previously considered are presented. Contributing factors to accidents occurring during Emergency Ascent training are set forth. Recommended training procedures to offset the contributing factors are presented ....

Within the next few minutes I will attempt to convince you of the value and need for Emergency Ascent training for sport divers. Having listened to the opposition to this training, and seeing the effect of this on some instructors, I feel it is important to present some information on Emergency Ascent training not previously considered. After defining what is we are talking about, the following areas will be presented:

1. Current status of Emergency Ascent Training
2. Arguments for and against Emergency Ascent Training
3. Causes of accidents during Emergency Ascent Training
4. Recommended training techniques

We will be talking about non-inhaling, vertical Emergency Ascents by scuba divers. These are not “free ascents” as conducted by the Navy and are not low-on-air ascents, but are ascents made by a scuba diver with no air except that in the lungs. We keep being compared to Navy ascent training when, in fact, we do not make unrestricted buoyant ascents at rates of 325 - 400 feet per minute from a depth of 50 feet. We recommend controlled Emergency Ascent training limited to a rate of ascent of 60 feet per minute from depths of 20 - 30 feet.

CURRENT STATUS

1. Emergency Ascent training is required for initial levels of scuba certification by all national certification agencies but one and by Los Angeles County.

2. All Emergency Procedures are under study by the training agencies, but the Emergency Ascent controversy is causing great concern.

3. The current controversy has forced realization that there must be agreement on Emergency Procedures, including Emergency Ascents, otherwise, we could have people diving together, trained by different agencies, who would react differently in an emergency. This could be disastrous.

4. Efforts are being made by a few people, such as Dr Eric Kindwall (1), Lee Somers (2) and Dr Nemiroff (3) to discourage or even prohibit Emergency Ascent training.

5. A survey (4) conducted among PADI Instructors in August resulted in the following statistics compiled from the first 150 questionnaires returned from active instructors in 34 states and nine countries:

    a. The first question asked, “How long have you been conducting Emergency Ascent training in open water?” The average length of time was 4.7 years.

    b. The second request was to estimate the number of Emergency Ascents conducted during open water training. The total was 63,263 or approx. 422 ascents per instructor.

c. The third item asked how many lung expansion injuries have occurred while conducting open water emergency ascent training. None were reported.

d. The final question asked, “Do you feel Emergency Ascent Training in Open Water is valuable and needed?” Only 19 were opposed. This means over 85% of the instructors responding are in favour of Emergency Ascent training in open water.

The fact that only a small percentage of instructors are opposed to open water Emergency Ascent training is consistent with the general opinion formed through discussion and correspondence with instructors on a daily basis from Headquarters.

ARGUMENTS FOR AND AGAINST EMERGENCY ASCENT TRAINING

Those opposed to the training involving non-inhaling, vertical ascents feel only a true emergency would warrant such action. They compare it to refraining from practicing the use of an ejection seat in an aircraft or jumping from the window of a hotel into a swimming pool in the event of fire. Those opposed feel the physical risk is too great and that the odds of an accident are too great to justify the training. They feel alternative training methods can adequately prepare the diver to successfully perform an actual Emergency Ascent.

Why should we conduct Emergency Ascent training? Because we have a moral obligation to; because a diver without air can only get to the surface two ways - assisted or unassisted, and we must prepare the diver for the unassisted situation; because it is one of the most significant exercises to increase student confidence and reduce anxiety; because it can prevent panic in a later emergency situation; because it is an excellent evaluation of diver composure and ability; because it works equally well in all geographical areas; because far too many accidents occur from divers attempting other emergency procedures at depths where an Emergency Ascent is easily performed; and because our personal experience and intuition tells us we should!

The opposers to Emergency Ascent Training point out the number of accidents resulting from Emergency Ascents, but all the information is not available to justify the movement to eliminate this valuable exercise. The University of Rhode Island 1974 Accident Study (5) indicates one accident due to Emergency Ascent training in 1974. During 1974, all certifying agencies required this type of training and the total number of divers certified during that year exceeded 200,000! Other accidents are attributed to Emergency Ascents when a closer investigation reveals the real problem was an unsuccessful attempt to buddy breathe, resulting in forced ascent.

Since some notable people oppose Emergency Ascent training, I decided to survey other notable people in the diving community to seek out those who advocate vertical, non-inhaling Emergency Ascent training in open water for sport divers. The following individuals have lent their support to my effort to re-enforce the need for Emergency Ascent training:

1. Dr Albert Behnke, one of the most distinguished men in underwater medicine.
2. Dr Glen Egstrom, UCLA Director of Diver Safety Research Project.
3. Dr Andrew Pilmanis, Diving Officer, USC Labs at Catalina Island.
4. Dr John Alexander, Respiratory Specialist
5. Dr Edward Hipp, Nalle Clinic
6. Dr Takashi Hattori, Pacific Grove Marine Rescue
7. Dr Thomas Noguchi, Chief Medical Examiner for Los Angeles County
8. Dr Charles Brown, Medical Editor, NAUI News and Medical Columnist for SKIN DIVER Magazine.
9. Dr Michael Strauss, Naval Regional Medical Center in Rhode Island

10. Jim Stewart, Diving officer, Scripp’s Institute
11. Four National Diver training organizations

Saying that Emergency Ascents should not be practiced because of the danger of lung injury is like saying we should not dive below 33 feet because of decompression sickness. I recall my early days of instruction when it was not uncommon for a student to bolt for the surface during mask clearing on a “check out” dive. This was hazardous, but we didn’t eliminate mask clearing. Instead, we figured out how to prepare students for the situation so they were relaxed and confident. We had them practice mask clearing in the pool with open water equipment, put their face in the cold water at the surface so flooding the mask underwater wouldn’t be such a shock, and clear their mask at the surface before clearing it at depth. These and other training techniques nearly eliminated the problem of students bolting during open water mask clearing.

It is very similar with Emergency Ascent training. We should no more eliminate Emergency Ascent training than mask clearing. If we have a problem, let’s not discontinue Emergency Ascent training, but develop the training procedures to get the student relaxed and confident.

CAUSES OF ACCIDENTS

It is pointed out that accidents occur even when “everything is done right”. What is right? There are no standards for Emergency Ascents, and therein lies the problem. I will show how a person could have an accident even when it appears that everything is being done correctly.

The following factors all contribute to a possible accident during Emergency Ascent training:

1. Medical Problems: It is possible for a student to have a lung defect which could lead to lung rupture during ascent. Colds or recent colds can also create problems. Professor Walden of the Royal Navy of England has reported that all embolism cases he has noted during ascent training have occurred to individuals who had had colds within the previous ten days.
2. Inadequate Preparation: Student readiness may, unfortunately, be determined by the number of hours of training rather than by individual ability and readiness.
3. Extreme Conditions: Students have been directed to perform as Emergency Ascent in very cold water with little visibility from an excessive depth immediately after descending from adverse surface conditions.
4. No Adaptation Time: A diver requires some time underwater to adapt both physiologically and psychologically. The student may not be permitted time to adapt to the environment, thereby reducing mental and physical capabilities.
5. Undue Stress: Lack of confidence by the student can create anxiety and apprehension which seriously affect performance.
6. Lack of Control: Instructors may have students ascend two or more at a time, not having control over the ascents. The instructor may also allow the students to ascend independently while only observing from below.
7. Looking Down: The instructor may be positioned in such a way that the student must look down at the instructor, thereby restricting the air passage. From personal observation, it is common for the instructor to be below the student during the ascent.
8. Rapid Ascent: Students may ascend at a far greater rate than 60 feet per minute, thereby increasing the possibility of lung expansion injuries.
9. Excessive Exhalation: It may be possible to embolize from exhaling too much during ascent, as pointed out in MAUl NEWS (6) and SKIN DIVER Magazine (7).

I think you can see how a student could have an accident when it appeared that "everything was done right". If adequately prepared, apprehensive, unadapted to the environment, recovering from a cold and exhaling excessively, the student might appear to be performing well while experiencing great distress.

These problems have been identified as contributing to accidents during Emergency Ascents. Now let's see what training techniques may be employed to offset these problems and reduce the risk.

RECOMMENDED TRAINING TECHNIQUES

PADI has required Emergency Ascent training for years. Recent changes techniques have been made, however, to offset some of the factors contributing to accidents that have been presented. The key to safe Emergency Ascent training is for the student to have confidence and for the instructor to have control. Both come from education and preparation. The following techniques help provide the needed confidence and control.

Preparation: An attempt should be made to discover any physical defects in the student. This includes completion of a medical history form and perhaps X-Rays and a medical examination for diving. These will only disclose defects, however. The type of defect which could lead to lung rupture can cause an accident during a normal ascent just as well as in an emergency ascent, and is not readily discovered. Requiring any more than a standard physical examination and X-Rays of students is not reasonable.

Once reasonably confident the student is physically able, begin to develop the skill. First, educate students until they are familiar with the physics and physiology involved. Describe the skill and explain the practical application. Explain the value and simplicity. Next, gradually develop the physical skill. Have students exhale when swimming underwater with skin diving equipment, exhale while swimming horizontally, exhale while swimming from the deep to the shallow end of the pool and exhale while making diagonal ascents from the deep end of the pool. Initial preparation involves knowledge, description, motivation and simulation. The skill must then be developed for open water, and the transitions are important. Teach from the known to the unknown. Assure student confidence and success. Have students exhale while swimming underwater in open water as skin divers, have them exhale while ascending diagonally in shallow water, have them perform vertical ascents from 10 feet, then 15 feet and finally 20-25 feet. Build confidence gradually.

The Open Water Exercise: The students must be thoroughly briefed to know what to expect. Establish signals such as "exhale", "stop", and "breathe"; have a common understanding of the sequence of events during the exercise: have a "dry run" out of the water where you simulate the ascent while you can still talk and answer questions; be sure students feel confident and at ease.

Some equipment is needed to provide a reference and control during the exercise. This consists of a surface float, such as a surf mat or inner tube, and a control line, marked at regular intervals to indicate depth, held down by 30-50 pounds of weight. This equipment should be set up in 20-30 feet of water with the line vertical and taut. See Figure A.

During the ascent, physical contact with the student and the line is mandatory. Should any difficulty develop, the instructor can arrest the ascent by wrapping a foot around the line (see Figure B) and restoring air to the student. The practice of wrapping a foot around a vertical line to arrest an ascent has been used successfully by the Navy for many years. The object is not to restrain a totally panicked student, but to monitor the person and prevent panic. It is extremely difficult to stop a person who decides to bolt for the surface. All you can do is try to slow the ascent and get the person to exhale. Your objective is to have them properly prepared for the exercise and to prevent panic by observation and control. The instructor must be positioned above the student and be equipped with an additional second stage to give to a student unable to locate his own.

PADI requires removal of the weight belt during Emergency Ascent training even though the instructor limits the rate of ascent to approximately 60 feet per minute using the control line to slow the ascent. In an actual emergency, a diver making an ascent from a depth greater than 30-40 feet should establish buoyancy to reduce the effort needed to reach the surface and to make sure it is reached, conscious or not. Some instructors point out that the diver will “rocket to the surface out of control” if the belt is removed. I believe many instructors take a strong position on issues without the benefit of much knowledge or experience. I conducted rate-of-ascent studies to determine how fast divers ascend after ditching weights and determined the following:

Sixteen instructor candidates in full 1/4 inch wet suits, neutrally buoyant at the surface, descended to a depth of 30 feet in calm water, ditched their belts from a kneeling position, totally relaxed and floated to the surface. Average time of ascent was 20 seconds! This could hardly be called “rocketing to the surface”. By flaring out, it is possible to achieve ascent rates approaching 60 feet per minute after ditching the weight belt. There are also other studies that indicate the average rate of ascent while swimming by sport divers is from 120 to 200 feet per minute during normal swimming ascents!

Whether or not the belt should be removed is not of great importance and neither is whether or not the regulator is kept in the mouth. I have argued about the regulator for years and have reached the point where it doesn’t matter as long as students make an ascent.

After removing the belt, the student should begin exhaling. Rather than blowing, have them pronounce “O” or “AH” all the way to the surface, as this keeps an open airway and helps prevent excessive exhalation. Notice we did not shut off the air supply, for this causes increased apprehension.

Have the student give two or three kicks to get started after beginning to exhale. It is best if the instructor signals when to begin the ascent. Agree ahead of time that the student is to take air any time it is offered, regardless of the circumstances. It is possible that something may not be right even though the student is performing correctly. An example would be an instructor equipment problem.

For the last 10-15 feet before the surface, the student should lean back and flare to slow the ascent just as would be done in an actual situation. See Figure C. The instructor continues to maintain contact throughout the ascent. It is necessary for the student to turn sideways when flaring as shown in Figure C.

After surfacing, the student pulls back down the control line to recover the weight belt.

Emergency Ascents performed to progressively deeper depths in this matter over a period of several open water dives provide safe and effective training for new divers and reduce the chance of an accident occurring. Simulated ascents while skin diving, etc., as set forth by some, are not acceptable substitutes for the actual practice. These are significantly different both physiologically and psychologically.

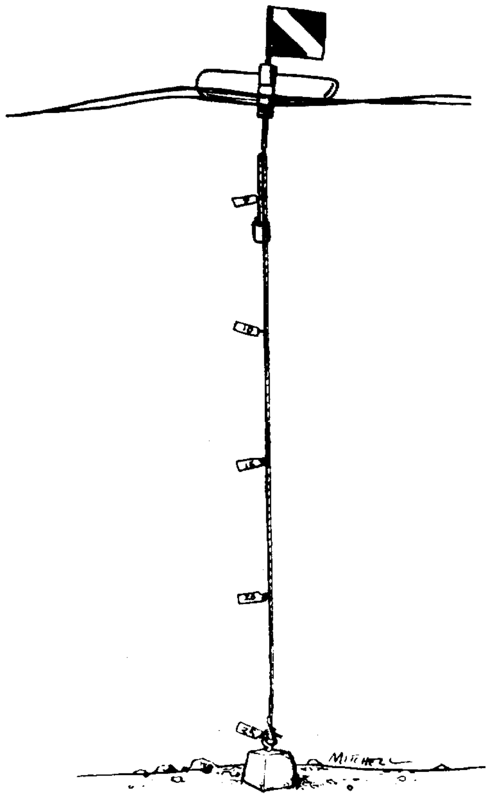


FIGURE A

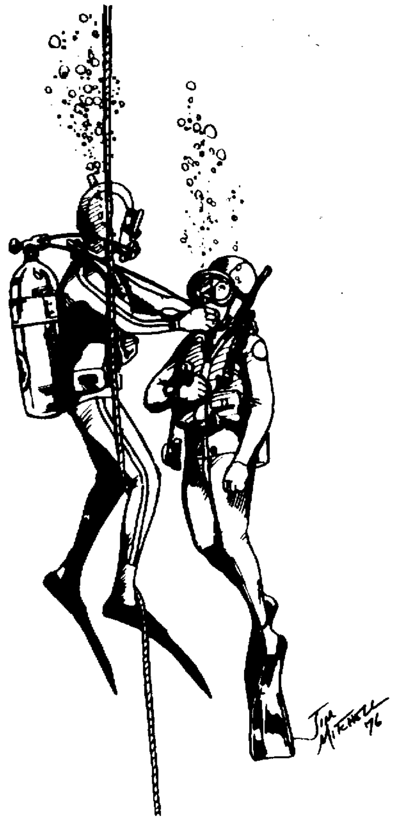


FIGURE B

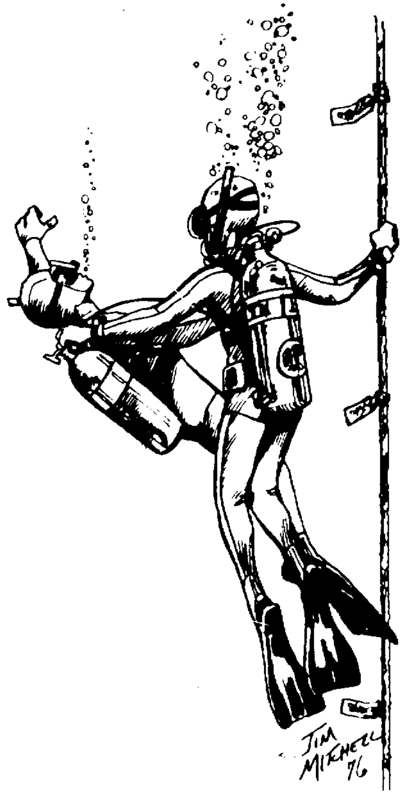


FIGURE C

SUMMARY

Emergency Ascent Training is essential and advocated by many experts. There is a need to reduce the chance of accidents and to standardize emergency procedures. While there are reasons why Emergency Ascents should not be practiced, there are other, more important reasons why they should not be practiced. The causes of accidents should be more closely studied and training techniques implemented to eliminate contributing factors. PADI sets forth a series of techniques and training procedures to reduce the risk to students during Emergency Ascent training by providing student confidence and instructor control.

The National Scuba Training Committee will be standardizing Emergency Procedures at the next meeting. We owe it to the diving community to reach an agreement on this matter. Please express your support of Emergency Ascent training to each agency with which you are affiliated. Who do you want to determine whether or not this important training should be conducted, the vocal minority or the silent majority? It is time for the 85% of you who feel Emergency Ascent training is needed and valuable to make yourselves heard.

* * * * * * * * * *

WOMEN IN HYPERBARIC CHAMBERS (ITALY)

Italian occupational safety laws prohibiting women from working in hyperbaric chambers recently became the subject of controversy. The Latin Region had organised a course for hyperbaric chamber technicians, which was open to both sexes. After the course was well under way it was found that a 1956 law prohibited such work by women. The author urges the repeal of this law, which denies the services of health care personnel to sick and injured patients, and which has apparently no basis in scientific fact.

(Medicina Subacquea ed Iperbarica, 1977, No 2, by MEMH)

* * * * * * * * * *

PREVENTIVE MEDICINE ... BUT YOU PAY!

* South Australia's Institute for Fitness Research and Training, which is affiliated with the Adelaide College of Advanced Education and has assessed and trained more than 7,000 men and women since the introduction of courses in 1969, is itself in danger of collapse.

* The reason is the recent amendment to the Health Insurance Act to disallow medical benefits (except for several approved organisations) for health screening services. People who enroll for the 12 week course are now faced with a personal bill of an extra $70 for tests they must undergo to assess their fitness for the course.

* The Institute's acting director, Miss Ann Davidson, says the Government's action makes it clear that it is not interested in promoting preventive health through the medical benefits scheme.

(AMA Gazette, 28 Sept 1978)

* * * * * * * * * *

A NEW APPROACH TO OUT-OF-AIR ASCENTS

GD Harpur, MD
Medical Director, Tobermory Hyperbaric Facility

(Paper for discussion at 1977 UMS Workshop on Emergency Ascent, December 1977)

The various instructor organizations in the world have been plagued for some time now with the problem of what to teach about emergency situations and how to teach it without incurring excessive risk to students and liability to themselves. Already rates for instructor insurance are climbing as the courts demonstrate willingness to increase the scope and degree of liability by their awards. This situation has lead to serious recommendations at national meetings of instructors organizations that nothing be taught to novice divers about emergency ascent, that it should be reserved for advanced classes. Such actions would be tantamount to suggesting that only pilots who survive the first year should be taught how to do emergency landings.

In considering the matter of emergency ascent we must of course recognize that once panic occurs our ability to influence the out-come ceases. The remainder of this submission is directed at the diver who is still in control in an effort to examine his options and hopefully to develop a logical course of action which if followed, will both prevent panic and ensure the safest possible ascent.

It is perhaps relevant to point out at this juncture that teaching a technique doesn't necessarily involve practicing it. The FAA suspended the practice of force landings because such practices too often turned into the real thing. In the same vein it should perhaps be pointed out here, that the inappropriate nature of the initial response to emergencies is what converts many mishaps to disasters. Professional instructor organizations have prepared various statements on ascent training culminating in the NSTC ascent agreement.

In this agreement which is quoted in the abstracts, the first two options to be presented to students are:

1. The use of octopus regulator;

2. Buddy breathing

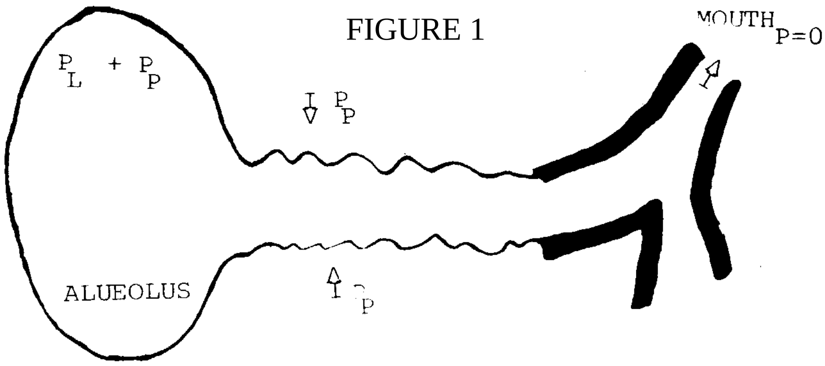
Both of these alternatives are taught in Canada as elsewhere, despite the fact that in our very cold waters doubling the mass flow through the first stage significantly increases the chances of freeze up which will deprive both rescuer and victim of air. Buddy breathing is also fraught with difficulty in waters which leave one's lips too numb to feel. Perhaps more significant are the omissions. No-where does this document mention the importance of psychological preparation. It fails to suggest immediate movement upward if difficulty is even suspected; worse it suggests evaluation before taking any action. Would it not be better to take conservative immediate action while evaluating, eg. signal to buddy and commence a normal ascent at once?

What remains to be determined now is the safest way of executing an emergency ascent, if this becomes necessary. A great deal of information exists about various methods of rapid ascent (buoyancy assisted) and as this represents the most extreme case any technique which is successful in this instance must embody principles important in all ascents. First, it has been apparent that a closed glottis is a potential hazard from earliest times. Passively holding the glottis open is a difficult feat; reflexes tend to close it at all times when respiratory activity doesn't require it to be open.

Recently in Toronto Sick Children’s Hospital, while conducting a study using physiologist physicians as subjects, Dr AC Bryan found only four of nine could perform this act. To avoid this problem Stenke advocated having the subjects head covered by a hood containing air and teaching them to keep breathing. The success of this technique shows the validity of his concept. Still there are failures. Some of these failures have been attributed by Boenke and others to small airway closure and subsequent air trapping. Techniques have been suggested to avoid this but to date no detailed explanation has been published relating the pulmonary dynamics during the ascent, to the potential hazards. We know from work by a large group of researchers including Macklem et al. and Fry et al. that we all produce closure of some small airways with each expiration, the precise percentage varies from 10% for healthy 18 year olds to 40% in 65 year olds. In water in a vertical position due to the pressure gradient applied to the chest wall, there is an increase in this trapping at the bases as shown by Dahlback and Lundren. If we examine now a sequence of alternatives for a hypothetical lung perhaps the difficulties will be more readily appreciated. As our principle concern is with sports divers a suitable depth from which to start their hypothetical ascents would be 50 feet with the diver starting at or near FRC as the diver most frequently becomes aware of his plight when he attempts to breathe in after normal expiration.

At this point (see Figure 1) the state of affairs in the lung can be represented as shown. The precise ration of patent to closed alveoli would vary with the lung zone. In the normal person above water, the collapsed segment reopens with the next deep breath or sigh. The diver cannot do this if he is out of air, but he has several options open to him. First, he may elect to blow down to RV and then hold his breath to the surface, or “blow and go”. As the glottis is closed during this manoeuvre, if the ratio of RV to TLV for the subject exceeds the ratio of pressures passed through during ascent, a burst lung will result. A young healthy diver will permit a ratio of RV/TLV of 1/3.5 and so will escape this problem in our hypothetical case. Older divers will not be as fortunate as their ratios may be exceeded depending on their respiratory status.

FIGURE 1



P_p = Pleural Pressure - Large
P_L = Elastic recoil of Lung - Small
As flow begins, resistance to flow causes pressure drop. Then eventually this drop = P_L.

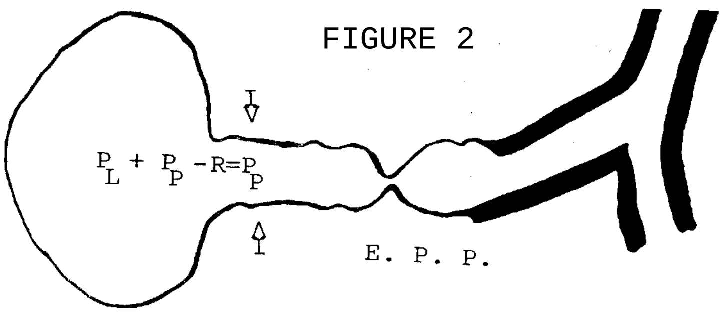
For the fortunate diver who escapes this consequence of Boyle’s Law let us examine the sequence of events in the lung as he rises towards the surface. The intrapleural pressure starts off negative. As the lung expands, it becomes less negative due to the attempt to rebound to FRV (FRV in water is lower than FRC in air), but as the gas in the lungs expands it too becomes positive. The forces which produced the airway closure are no longer operative. The lack of interdependent forces has been restored by parenchymal expansion. The dynamic flow situation leading to the locating of the, Equal Pressure Point of Mead, Macklem and others within the collapsible segment of the air-way is no longer present, as the glottis is closed and flow has ceased. In addition expanding alveolar gas leads to increasing alveolar pressure which assists in air-way opening in conclusion then this would seem a reasonable approach for young divers with no anatomic anomalies or scars which might lead to the trapping of excess gas provided they can be certain they are in 60 feet or less of water.

The next alternative is the most widely taught response. The diver rises to the surface blowing out as he goes. If we examine this situation a potential hazard becomes apparent. If one of the alveolar units closed during the expiration contains more than 1/3 of its potential volume and if the diver maintains expiration to the surface, from 50 feet it may rupture. Note that the first alveolar units to close, are those with the lowest elastance or highest compliances. The continuance of these expirations maintains the dynamic flow force which produced the closure, surface tension forces assist in this regard and interdependence forces are prevented from becoming significant by the lack of lung expansion. Any interruption in this expiration, especially any attempt at inhalation, can rapidly alter this sequence of events. A fact which I feel has saved many divers. Whether the pressure required to burst an alveolus in this situation is lower than that required to open the closed airway has not been proven but the possibility exists and would explain most of the unmerited burst lungs we see.

The next alternative to be explored is the possibility that the diver could ascend attempting inspiration all the way. In this situation the pleural pressure remains negative at all times. The interdependency forces grow as the lung expands assisting in opening closed airways. The glottis is open and the airways maximally patent so out flow resistance is minimal and the gas free to behave in accordance with the dictates of Boyle's Law unless the ascent rate exceeds the maximum rate seen with the Stenke hood, which is improbable, the way flow rate generated by the effects of Boyle's Law would be of the order of 3-4 litres per second which is well within the limits of rates measured in exercising. This then might be the best of the alternatives for very rapid ascents but needs further investigation and because the procedure is psychologically difficult it may never be the best for sports diver.

Sports divers rates of ascent even when buoyant would rarely approach 200 feet minimum unless using unisuits, but the benefits of the continuous inspiration may be achieved in most cases by simply maintaining a cycle respiration. This will ensure the glottis is kept open and that pressures are cyclically altered so that in the inspiratory phase, opening of small airways is encouraged. The students should be taught to emphasize deep inspirations and to increase the rate of respiration with the rate of ascent.

FIGURE 2



Once closure occurs - How does it reopen? - Surface tension holds it closed if lung volume decreases. Little elastic recoil and P_L very small.

At the rate of ascent encountered in submarine escape, a normal rate of respiration could easily lead to the subject being in expiratory phase all the way from 60 feet to the surface and thus resulting in a burst alveolar unit. This could perhaps be avoided by either continuous inhalation or rapid panting at relatively higher lung volumes during ascent.

As an instructional unit our next concern here was with methods of instruction. To reduce the psychological shock caused by out of air situations, we teach all our students to expect to run out of air on every dive. We teach them to do the usual safety check, and to use underwater gauges and octopus regulator. We also teach them not argue with their gear, under water. Regardless of what the underwater gauge says, if you are having difficulty getting air comfortably, signal your partner and start up gently. If the problem is progressive, the time saved by the immediate start up may prevent panic and save life.

To train actual emergency ascent we proceed as follows. In the pool, we have students swim up along the bottom slope breathing in and out, we increase the speed and emphasize the need to breathe in and out. Next in 10 feet of water we shut off the students tank with a hand on the valve, watch to ensure they encounter the difficulty (ie. breathe out and fail to get air), then swim with them as rapidly as possible up the slope watching to ensure that they seem to attempt to maintain a cycle of respiration. This procedure is discussed and repeated as often as needed to get the student comfortable. We repeatedly emphasize that you maintain breathing in and out or attempting to do so against dry regulator or closed lips, and that you increase the rate of this cycle if you are ascending more rapidly. Finally we repeat the drills in open water using repeated swimming and buoyant ascents with air on to depth of 25 feet and air off ascents gradually increasing from 10 to 30 feet on a tethered line, one on one, instructors hand on the air valve.

For special candidates who dive with unisuits (eg. Canadian Government Arctic divers), we also do progressively staged blow ups from depths to 30 feet using high lung volume panting routines. One difficulty we encountered in this group of divers was unique to the air filled suits. A somewhat stocky diver who fitted his suit rather well, especially at the wrist and neck seals, got into severe difficulty at the surface because of the high pressure retained in his suit. It took fast action on the part of his tender to rescue him from this dilemma.

For these concepts to be accepted as valid, certain questions remain to be answered. Can it take more pressure to open a collapsed small airway than that required to rupture the alveolar wall? Answers to this are hard to determine. Studies of the pressures required to open small airways have all been done on intact lungs which, because of the interaction of hydraulic and mechanical forces may behave quite differently from the isolated alveolar unit which may have only hydraulic forces acting on them. Typical figures cited for such intact lung studies give pressures of 4.5 cms H_20 (Burger and Macklem) to re expand collapsed airways. If we look at a single collapsed airway of radius “r”, the pressure required to open it is presently not known. We are attempting to find a modification of the La Place law that might cover this situation as a starting point. The burst pressure of an unsupported alveolus is similarly unknown as indeed is the burst pressure for a terminal respiratory unit divested of support from surrounding units. While these and many other questions are being explored and hopefully answered several important changes can be made in current practices without hazard.

1. Instructor organizations can standardize their teaching

2. Regulators can be left in the mouth and attempts at inspiration made during ascent which will:

   (a) reduce tendency to panic
   (b) provide air from the tank thus delaying onset of hypoxia
   (c) reduce any chance of alveolar rupture due to trapping

There remain other problems but perhaps from this workshop there will be the beginnings of an organized effort to eliminate these gaps in our knowledge so that some definitive solutions can be found.

THE AMBULANCE IN THE VALLEY
Anon.

"Twas a dangerous cliff, as they freely confessed,
     Though to walk near its crest was so pleasant;
But over its terrible edge there had slipped
     A duke, and full many a peasant.
The people said something would have to be done,
     But their projects did not at all tally.
Some said "Put a fence 'round the edge of the cliff,'
     Some, 'An ambulance down in the valley.'

The lament of the crowd was profound and was loud,
     As their tears overflowed with their pity;
But the cry for the ambulance carried the day
     As it spread through the neighbouring city.
A collection was made, to accumulate aid,
     And the dwellers in highway and alley
Gave dollars or cents – not to furnish a fence –
     But an ambulance down in the valley.

'For the cliff is all right if you're careful', they said,
     'And, if folk ever slip and are dropping,
It isn't the slipping that hurts them so much
     As the shock down below – when they're stopping.'
So for years (we have heard), as these mishaps occured
     Quick forth would the rescuers sally.
To pick up the victims who fell from the cliff,
     With the ambulance down in the valley.

Said One, to his pleas, 'It's a marvel to me
     That you'd give so much greater attention
To repairing results than to curing the cause;
     You had much better aim at prevention.
For the mischief, of course, should be stopped at its source;
     Come, neighbours and friends, let us rally.
It is far better sense to rely on a fence
     Than an ambulance down in the valley.'

'He is wrong in his head', the majority said;
     'He would end all our earnest endeavour.
He's a man who would shirk this responsible work,
     But we will support it forever.
Aren't we picking up all, just as fast as they fall,
     And giving them care liberally?
A superfluous fence is of no consequence,
     If the ambulance works in the valley.'

The story looks queer as we've written it here.
     But things oft occur that are stranger.
More humane, we assert, than to succour the hurt
     Is the plan of removing the danger.
The best possible course is to safeguard the source
     By attending to things rationally.
Yes, build up the fence and let's rely less
     On the ambulance down in the valley.

<u>A SEA WASP ATTACK IN WESTERN AUSTRALIA</u>
(Carybdea Alata)
(The following report is based on an Incident Report kindly submitted by the victim. Editor)

The victim was a healthy man, a trained diver of considerable experience, who had past experience of stings from Portuguese Man O'War in Guam, Hawaii and Australia. He had suffered no reaction other than localised pain for about an hour from such contacts. He had suffered minor skin reactions from various common jellyfish, fire coral, stinging hydroids, sea urchins and crown-of-thorns starfish and was well acquainted with all forms of venomous sea life. The reaction he suffered in this incident cannot therefore be ascribed to hypersensitivity on his part to marine stings.

During the few days prior to the attack the wind had been blowing from the north east during the day and at the exact time of the attack was 15-25 knots out of the south-east, causing the area of the incident to be protected from all except large rolling waves.

The victim was a member of a party walking on Point Mural beach near the pier at about midnight, 11 March 1978. He was the only one in bathers so went down to the surf line to examine the possibility of having a swim. It was quite apparent that the wind and waves were too much to be enjoyable so he turned to leave the water. At that time, breaking waves would bring the water up to his knees when it came in: it was before high tide.

The following description is in his own words:

"I felt a gelatinous substance brush by my right foot and felt immediate pain. I knew it was a jelly fish and quickly left the water. I walked back to the parking lot and went to the rear of a truck where there was light enough to see there were no tentacles attached to my foot. I went to the rear of my own truck and got a gallon of fresh water to flush the area since the pain was steadily increasing. As I flushed it, I began to realise that I was into something other than the normal jellyfish of the Exmouth Gulf area and cursed myself for having removed the medicinal alcohol that I normally carry in the rear of my truck. I walked around for a few minutes hoping that the pain would abate. It didn't, so I told my wife to drive me home. About five minutes had elapsed and I felt a slight "knot" in my lower abdomen. I crawled into the back of my truck with one of my friends and we left the area. By the time we had driven 400 meters back to the pier road, the "knot" had progressed to just below my rib cage and was beginning to interfere with my breathing. I told my wife to drive directly to the navy dispensary (6.8 miles). My breathing became quite distressed as the stomach and chest muscles became quite rigid and made it seem I was not getting enough fresh air. The trip took but a few minutes and they carried me in and put me on the table at the US Navy dispensary at precisely 12.25 am on 12 March. Although the pain was still primarily in the foot, the laboured breathing was the thing bothering me most. They put me on free-flowing medicinal oxygen but it didn't seem to help much. By this time the feeling of pain was everywhere and it seemed to be emanating from the base of my spine. Along with the pain I was aware that I was losing motor control over everything below my neck. My skin was cold and clammy and I perspired profusely. Eventually the pain went up the back of my neck and into my head. I was being quite vocal about the pain and it took until approximately 2.15 am before the attending physician had stabilised my condition to the extent that they could move me to Exmouth District Hospital. The treatment in the hospital alternated between cortisone injections with IV and pain killer every hour until late Sunday evening.

By this time the pain was localised in my right leg and left foot. It moved up and down my right leg depending on how long it had been since the last pain killer injection. I noticed that both feet hurt consistently until around 2.30 am on Monday morning. From that time on I did not require any more shots for pain.

I remained in the hospital Monday night for observation and was released Tuesday morning, 14 March, for three days off duty. In those three days the remaining problems consisted of sore body muscles, a bad case of diarrhoea, recurring bad dreams, chills, twinges of pain in the affected foot, numbness of the skin on the affected leg, vision problems in my right eye, headaches and a general weakened feeling. Weight loss was 7 pounds.

There were no scars from the point of contact with the jellyfish, but the instep of the right foot had four areas of small red spots. The skin was treated with Squibb Kenalog Cream. Any contact with salt water caused intense stinging in the foot. On April 3rd, the red spots progressed to the point that I could count approximately 90 individual spots in the four stung areas on my instep. These gradually disappeared between April 3rd and 10th. It took until 10th April to regain my former strength. The only permanent effects of the sting as of 3rd May appear to be the weakened vision in my eyes and the tendency for my right foot to give way under weight on occasions.

The morning after the attack my wife went back to the beach and found at least six dead specimens of jellyfish on the beach. The “bell” was the only thing left and it measured up to 10 inches in length: photographs were taken of a specimen and later identified as Carybdea Alata. An attempt was made by some local divers to locate some of the jellyfish in their natural state shortly after the attack but was unsuccessful”.

We are pleased to be able to present this excellent report of a Box Jelly sting described in accurate detail by the victim. His public spirit in preparing and making it available is greatly commended.

* * * * * * * *

SEA SECRETS - (May-June 1978)

QUESTION: Is it feasible to use dolphins to patrol beaches and chase away sharks? (DW, Shreveport, Louisiana)

ANSWER: Experiments were conducted in the early 1970’s at Nite Narube Laboratory. Sarasota, Florida to determine the feasibility of using dolphins as an antishark device. A male bottlenosed dolphin (Tursiops truncatus) was caught in the Gulf of Mexico and placed in a large tank at the laboratory. Initial tests with the animal, which was named Simo, suggested that bottlenosed dolphins and some species of sharks are not natural enemies.

The Mote researchers were able, however, to train Simo to attack and drive off several species of sharks. The only shark that Simo refused to attack was a bull shark (Carcharhinus leucas). Considering, however, the relatively low numbers of dolphins compared to sharks, as well as federal restrictions on capturing and molesting dolphins, the idea of using these marine mammals to patrol beaches is probably not feasible.

(from *Sea Secrets*, International Oceanographic Foundation, May-June 1978)

* * * * * * * *

AN INCIDENT DURING POOL TRAINING

David Mclvor, PhD, BSc (Hons)
Regional Director, Victorian Region, FAUI

This is an incident that occurred while I was personally involved in training some University students in the use of Scuba, in a swimming pool.

I was instructing a group of four, two boys and two girls, on the second night of their course. The group as a whole was progressing rapidly and appeared to be in no bother with finning, mask clearing, swimming without mask, and removing/replacing regulators. The incident in question occurred during the introductory buddy breathing session.

After a few minutes practicing buddy breathing with them in the shallows, I instructed both groups to swim two laps of the pool whilst buddy breathing. The two girls had swum some one and a half laps (100 m) and were at the 7 foot mark of the pool when the girl who was receiving air stopped swimming, gave the “up” sign to her buddy, and slowly commenced to ascend ... exhaling all the way. However, about a foot from the surface she faltered, appeared to cough several times and began to sink again, now making no effort to regain the surface. Fortunately I was about two feet away from her during this ascent and was able to bring her to the surface as soon as she began to sink, probably within 5-10 seconds. I then removed her mask, brought her to poolside, removed her tank, and lifted her out of the water. During this time she was attempting to cough and retch. She was placed in the coma position, neck and throat extended, and covered with towels. At the stage she was pulled from the water she appeared semi-conscious (at best) and was coughing up fair amounts of clear mucus. She can recollect nothing from this period. After about a minute in this condition she appeared to regain full consciousness, clearing her mouth of mucus (I checked the colour of the mucus) and kept saying that she couldn’t remember what happened. Having now recovered, except for pains in the lower chest, she was allowed to go and change, assisted to the change rooms by her girlfriend.

“I then range Dr X to discuss the incident and get his recommendation: he had given her a Diving Medical the week before. He agreed that she be taken to the nearby hospital, which had a good thoracic unit. After she was dressed she still complained of a sore chest and had developed a rather raspy cough. At this stage she admitted to a slight bout of bronchitis the week before. I then drove her to the hospital, where she was admitted to outpatients, examined by a doctor and had an X-Ray taken before being allowed to go home with instructions to return the next day for a check-up.

However, as a Senior Instructor from a reputable diving school I felt well enough informed to voice my concern at the attitude shown at the hospital. After my student had supplied her details to the person on the desk I was asked to supply further information on what had happened. I gave them the same details as supplied here, viz., semi-consciousness, clear mucus, coughing underwater (and therefore possible inspiration of water), chest pain, etc. I warned them of the possibility of some barotrauma and urged the hospital to contact Dr X, “who was an expert in the field of diving medicine”, for further information. The person in charge, after some hesitation, wrote his name on the very top of the page, which proved to be the butt of the tear-off form which was given to the examining doctor. So much for my recommendation! It was some ten minutes later (after a possible near-drowning and lung rupture event) that the patient was taken away for examination, still coughing and complaining of chest pain. Five minutes later the doctor came and asked me some questions, one of which was “Is there any chance of bends?” I replied that this was unlikely in a 7 foot pool and repeated my recommendation that Dr X be contacted as he was familiar with the case and with diving medicine.

The doctor told me rather frostily that she had done some diving and was therefore familiar with the problems!! I then told her that Dr X had even suggested that the patient may have to be kept overnight and that if Dr X was not contacted then I would ask to speak to the Senior Doctor on duty (a tactic suggested to me by Dr X if I was not satisfied with the treatment). There were no bad feelings, just persistence on my part. Anyhow, Dr X was contacted, the case discussed, an X-Ray taken, and the girl allowed to go home.

“There were some additional facts that may be of interest in relation to this incident:

1. The student had had a lot of difficulty with the standard swim test (200m swim, 2 mins tread water, duck dive) and in fact had to have two attempts (on two nights). From my experience, people who have trouble with the swim test will have some trouble with aspects of the course .... call it watermanship if nothing else more quantitative.

2. The student has a small face and consequently had some trouble finding mask to fit. She also had some trouble with water up her nose from this complaint (see item 1). However this problem appeared to have been overcome.

3. I had followed the two students into the deep section of the pool and was only 2 feet away from them when the incident occurred. I found it interesting how she appeared to give up her attempts to reach the surface. I feel that she would have drowned if left to her own efforts. <u>Moral:</u> be with students when they are in deep water.

“As a personal comment I would add that I believe it is incumbent upon SPUMS to inform staff of hospitals, particularly casualty departments, of the proper procedure to follow for diving accidents. This should include a list of telephone numbers of people to contact in an emergency or if in doubt. Furthermore, I believe that just as diving instructors have had to accept the medical world’s interest and opinions in matters of diving instruction, so must the medical world be encouraged to accept that diving instructors (or at least FAUI 3 Star Instructors) do have some specialist knowledge of diving medicine and can certainly supply detailed information relevant to diving injuries. Such information should not be patronisingly dismissed as “coming from a non-medically orientated lay person.”

(EDITOR: This article provided both an interesting case report and an acute assessment of the correct status of the trained diving instructor vis-a-vis diving problems. It may be noted that is has for long been the policy of SPUMS to welcome diving instructors and interested divers as associate members and the journal has used many lay articles.)

* * * * * * * *

NB: *All “Sea Secrets” and “Sea Frontiers” articles appearing in this issue are reprinted from “SEA SECRETS” the official magazine of The International Oceanographic Foundation.*

* * * * * * * *

A DIVING INCIDENT
Contributed

At the SPUMS meeting on Suva (June 1978} Dr Glen Egstrom mentioned that there had been a few unexplained deaths in middle-aged men who appeared to be in good health. The story was that they surfaced normally from a normal dive and then suddenly got into trouble on the surface and drowned. They did not appear to have suffered a heart attack.

On Sunday 1st October 1978 a 49 year old male mildly hypertensive (150/100) and on Enduron (Methyclothiazide), but otherwise healthy, went for a boat dive off Barwon Heads. There were twelve divers and two boatmen. He and his buddy were the second pair into the water. There was quite a current and the swim to the anchor line was tedious. The diver attributed his rapid respiration to the cold water. He had not had a dive in Victoria for 18 months. He had felt, as always, exhausted by the time he was kitted up in a 1/4 inch wetsuit, tank, and 30 lb weight belt. (On the last dive he had been neutrally buoyant at 18 feet with these weights). He was unable to take his pulse after kitting up as he could not reach a pulse. He was buoyant at the surface with no air in his buoyancy compensator (Fenzy).

The two made their way down the anchor rope and slowly the diver’s breathing slowed down and he began to enjoy the dive. Bottom was 20 metres and the dive site was a small reef rising off a sandy bottom, with much interesting algal life, sponges, corals and fish. There was a bit of surge washing over and through the reef. When the diver had 50 bar remaining (735 psi) the two started their ascent. They could not see the anchor rope. The diver vented air from his Fenzy as he rose. However he did not note the time of leaving the bottom and neither did he watch his (capillary) depth gauge on his contents gauge as he ascended. The bourdon tube gauge on his wrist had not worked throughout the dive. Probably he rose faster than 60 feet/minute.

On reaching the surface he rotated, looking for the boat, inflated his Fenzy and found that he was breathing rapidly but felt unable to get an adequate amount from the regulator (Poseidon). About this time he noticed a large black seabird almost within pecking distance which was observing him with either disfavour or interest. So he started to swim slowly towards the boat which was some ten yards away. The Fenzy did not appear to be keeping his face out of the water so he inflated it a bit more. All inflations were from the bottle. This made the Fenzy too tight for comfort so he deflated it a bit. By now he realised that he must stop and rest and try to control his breathing, as he was feeling frightened and quite unable to control his breathing enough to swap to his snorkel. He drifted to the boat and hung onto the anchor rope with one hand and then took his regulator out of his mouth and put his other hand on the anchor rope. He desperately wanted help from the boat but the people a foot or so above him just sat there. He asked someone to take his weight belt, wanting it taken off him by someone else. Someone said “pass it up then” and he realised that he was panic-stricken, then he began to think and let go of the anchor rope with one hand as his buddy swam up. The weight belt had a quick release and as it was released it slipped from his grasp and was missed by the buddy. Even with the weight belt he had been floating with his face well out of the water but nevertheless had been obsessed with keeping his face out of the water. About this time he realised that he was wheezing, something that he had never experienced before. With his buddy’s help he put his snorkel in and made his way down the boat to the ladder.

The boat had a freeboard aft of about one foot and the ladder had three rungs under water. He was sensible enough to try to get out of his backpack as he had no intention of attempting to get up the ladder with any weight he could shed. His breathing was still out of control. Even without tank he was unable to pull himself up into the boat and without the two boatmen he would have been lost. Once in the boat all he could do was sit in the stern and breath rapidly and deeply. Over a period of about five minutes his respiration slowed down and became normal again. Both he and his buddy attributed his exhaustion to being unfit. The total time of the dive was about 22 minutes.

While driving home, having spent a further hour on the boat, he thought about the whole incident. He normally had difficulty controlling his breathing in the water on entry, especially after a lay-off, and his last dive had been in Suva in July. He had no problems at all till he reached the surface and then both respiration rate and tidal volume increased. By the time he reached the anchor rope his only interest was in getting enough air. At no time did he feel his heart beating or feel exhausted physically. In his youth he had rowed and could clearly remember the feeling of physical exhaustion and the laboured breathing of extreme exertion. This breathing was not like that, he was at rest yet the respiratory drive did not decrease.

He wanted to remove his hood and undo his wetsuit, he felt restricted. Once his respiratory rate had slowed down he felt fine.

The diver is an anaesthetist and he remembered that the earliest recognition sign of venous air entrainment during operations on spontaneously breathing patients is an increase in depth and rate of respiration. The books do not say how long it lasts but one would expect that it would last until the bubbles trapped in the lungs have disappeared. This made him think that it was likely that he had ascended too rapidly, generated a crop of venous bubbles which had been trapped in the lung and produced the increase in rate and depth of respiration over which he had no control. He only survived his panic because he was close to the boat and had a helpful buddy.

D'ARRIGO has shown that a pressure deduction of 1/5th of an atmosphere produced bubbles in agarose with rapid decompression. It seems likely that a rapid ascent even from 20 metres could produce bubbles in venous blood, even if the overpressure is not enough to produce enough bubbles to give symptoms of "the bends". The bubbles in the lung capillaries would dissipate over a few minutes if there were no fresh ones joining them.

Although he felt restricted in his breathing this was only after he had inflated his Fenzy, which was on short straps and pressed hard against him. While the chest restriction may give rise to rapid respiration it positively inhibits deep respiration and his respiration was fast and deep. It has been suggested that his problems were due to chest restriction from his wet suit, Fenzy and gas in his stomach. This seems most unlikely as this could explain tachypnoea but not deep respiration. There was no chance of carbon dioxide retention as he had not exerted himself underwater.

The lesson is to ascend slowly (if the above paragraph is true). This is the first time for ages that the diver has ascended without his watch and depth gauge held out in front of him. He suffers from presbyopia and needs his reading glasses to see the instruments clearly. He has a pair of lenses inside his mask but they were too fogged to be of use and the visibility was poor so he concentrated on keeping an eye on his buddy and not on the instruments.

Perhaps this is what happened to those mentioned in the opening paragraph. Possibly they similarly developed this rapid, deep, uncontrollable breathing and got water in the snorkel. They would then pass from worry, through panic to drowning.

* * * * * * * *

Provisional Report on Australian Diving Deaths in 1977

Dr Douglas Walker

Overview

Five deaths have been identified but the limitations of the system used to detect the occurrence of fatal incidents (voluntary notification by interested persons, and newspaper reports if the cases occur when nothing more newsworthy has occurred) make it probable that the total is higher. There were two breath-hold diver and three using scuba. Improvident actions contributed to these deaths, gross inexperience being present in all the scuba victims. While this factor can never be eliminated it is hoped that consideration if these cases will alert trained divers to the great disservice they do to a friend if the either lend their equipment or condone the use of their good name to allow an untrained person to obtain and use scuba equipment. The factor of cold was mentioned in two fatalities, another reminder that youth and determination alone are no guarantee of safety. The wearing of buoyancy vests would have made four of these deaths less likely. Several safety violations were present in all the cases, none being the penalty of a single mistake.

Cases

The following brief reports are based in part on information presented at Inquests and in part on newspaper and other sources. Information available is not always as great as would be desired and readers are requested to involve themselves in supplying information, not limited to fatalities, to broaden the scope of the investigations. Confidentiality is always afforded to such reports.

Case BH 77/1 This victim was with two companions in an area where people dived for abalone. He was reluctant to dive this day because he had no wet suit and the water was cold and choppy. The three divers swam from the beach, separately, to a reef about 100 m off shore. He was seen to surface suddenly from a breath-hold dive, clutch his stomach, and then disappear from sight. One of his friends swam to offer assistance but was unable to find him. The other diver remained ignorant of the incident until he had completed his dive and returned to the beach. The body was not recovered till the next day, by which time it had been damaged by sharks. He was said to have been a good swimmer and to have skin-dived before. It is thought that the body was mauled after death. Through a misunderstanding concerning the degree of body loss, only the external examination of the body was ordered and no internal organs were examined so no type of useful medical evidence is available. Death is assumed to have resulted from drowning.

Case BH 77/2 The danger of diving alone is apparent in this simple tragedy. He was a good swimmer, spear fishing while his father sat in the boat and line fished. His float was observed to be remaining unusually still so, after watching it for about 10 minutes, his father pulled up the line and found his son floating without moving. He brought the body into the boat but resuscitation attempts failed. Water depth was 18-21 m (60-70 ft) and the sea calm. Medical evidence was given that the victim had a probable epileptic history, though a specialist physician who investigated him about 17 months before this incident reports that the E.E.G. was normal. Nevertheless he had been prescribed Dilantin, it being felt that both faints and fits had occurred previously and were possibly stress related. It is not known if he took his suggested medication. Hyperventilation, which was almost certainly practiced by any experienced spearfisherman operating in 18-21 m (60-70 ft), could have led either directly to an anoxic blackout or induced a fit. As he was diving alone, drowning would inevitably follow.

Case SC 77/1 A friend was introducing this young man to scuba diving. The day before he made a 10 minute dive, apparently his first ever. The sea conditions seemed good so the friend called him into the water for what was to be the fatal dive. He had a borrowed scuba set. After about 5 minutes of check-out in the water he was judged to be alright and it was agreed that they would dive and swim across a sandy area, water depth about 4 m (12 ft), to reach some rocks. The friend led the way, about a length and a half in advance of his "pupil". Apparently the leader surfaced to check their position and was unable to find the victim on returning to the sea floor. He searched visually without success until he saw somefins floating at the surface, shortly afterwards finding his friend lying on the sea bed. He brought him to the surface and onto some rocks, semi-conscious and without mask or fins. Resuscitation was attempted by use of the regulator but waves washed him back into the sea several times, till the rescuer himself was in trouble and calling for assistance to get back onto the rocks. He was assisted to leave the water and the victim's body was recovered shortly afterwards from 2.4 m (8 ft) of water, still wearing the weight belt. Neither wore buoyancy aids.

Case SC 77/2 An occupational risk of professional fishermen is the loss of their trawl nets on sea floor wreckage or rocks. On this occasion the fisherman obtained a quotation for recovery of his nets and decided the cost of a professional diver would be excessive. He therefore went to a sports store and hired scuba equipment to enable him to do the job for himself, a procedure he had followed on a number of previous occasions. His first attempt was only partially successful as he used up his air supply before completing the job. He was diving in a tideway so was seen by the harbour police launch crew, who stopped by to suggest, politely, that he should notify the Marine Service of his proposed activities. They also lent him a "Diver Down" flat to display. On this occasion he was wearing a home made weight belt over his overalls, though the next day he wore it beneath them. He was questioned about this by the friend he took with him the next day to manage the boat while he dived, but did not change the arrangement of his equipment. He was wearing desert boots, socks, a skivvy and two jumpers under the overalls, and had a knife, spike, shifting spanner and line attached to his waist. For this second attempt to release his net he hired two tanks to ensure that he was not thwarted by running out of air again. The water was rough and the wind was gusty. He had neither fins nor a buoyancy vest, however there was a contents gauge on the hired tanks. He was seen to surface after freeing the net, appearing about 36 m (120 ft) in front of his boat. It is thought that his mask was off and that the demand valve was not in his mouth when he was seen on the surface. Not unnaturally he seemed to be having some difficulty in remaining at the surface. He disappeared before the boat could be brought to his position. According to the police the victim was an experienced snorkel (breath-hold) diver but had only used scuba about six times, usually to free his nets. The sports store keeper declared that he had frequently hired equipment over the preceding 6-7 years, and that as a "licensed fisherman" he could be expected to know how to dive. Another dive shop had refused to accommodate his request to hire tanks as his qualifications were doubted.

Case SC 77/3 This young man was making his second scuba dive, the first having been in a protected pool used for diver training. His friend had his own equipment and his certification card. The card was presented to ensure the hire of a scuba set, which was then handed to the victim for his use. The water visibility was poor and the sea was sufficiently cold for the buddy (trained) to suggest terminating the dive after about 10 minutes. They were diving from rocks into water up to 11 m (35 ft) deep. After about half an hour, a check of contents gauges showed that the pressure was down to 500 psi. They started to ascend together. Owing to the difficulty of making a successful exit onto the rocks, which were being washed over by waves, the buddy was fully occupied by his own problems for a short time. When finally out of the backwash, he took his mask off and looked around for his friend but was unable to sight him. A nearby rock fisherman called that he had seen a diver in difficulties so he began an urgent search, but was hampered by the loss of his mask.The mask had been washed away into the white water while he recovered from the exertion of his exiting problems. Other divers joined the search and the body was found about 6 m (20 ft) seawards from the position of last sighting. According to one of the searchers, a strong current was running. It is possible that the victim made an unsuccessful attempt to leave the water but was drowned after being washed off the rocks and tumbled about in white water.

Discussion

In no case was a buoyancy aid worn. All were either diving alone or had separated from their companion at the critical time. Except for the diver who had an epileptic history and was probably a "post-hyperventilation blackout" victim, a buoyancy aid could have greatly improved the chances of survival. In two cases it is presumed that cold was a significant factor. None of the four scuba divers were in any way adequately prepared to manage their scuba equipment if faced with any untoward event. Case SC 77/2 is almost an object lesson in how not to dive. It is worth noting that the survival of a diver cannot be taken to indicate that his methods and knowledge are worthy of emulation. "Experience" is a teacher to be viewed critically! His death may have been from an air embolism, but as the body was not recovered for a week this could not be demonstrated. It is very unfortunate that these three persons were able to borrow or hire scuba equipment, for had it been otherwise they would still be alive. The need to assess the ease of leaving the water before entering is underlined in the last case, it being the final critical error. As has been noted other reports, there are almost invariably a series of negative factors present which contributed to the fatal outcome. Often the correction of any one would have altered the outcome. One should not only be trained to survive at least moderate misadventures but learn to assess the conditions so as to avoid attempting more than is within the capabilities of the lease able of the party. Have a buddy and a buoyancy vest and you are likely to live to tell your own diving story.

ACKNOWLEDGEMENTS

This report would not have been possible without the help of those who send in notification of incidents and the provision of copies of Inquest proceedings by the Attorney General's and Justice Departments in all States.

Project Stickybeak

Reports on diving related incidents of every type are desired including fatalities, as safety depends on the recognition of potentially dangerous circumstances while avoidance is still a simple matter. Safety also depends on making the correct response to such situations should they occur, and reports from those who have successfully met the test would share their knowledge with others. Confidentality is guaranteed to all correspondents.

Please write to Dr D. G. WALKER
P.O. BOX 120
NARRBEEN N.S.W. 2101

THE IMMEDIATE MANAGEMENT OF THERMALLY UNBALANCED CASUALTIES IN THE FIELD

Dr David A Youngblood MD, MPH and TM

This paper was presented at the Seminar on Thermal Problems in Diving held at the Commercial Diving Centre, Wilmington, California, 19-20 March 1976 and hosted by that organisation. We are grateful to the Author and the CDC for permission to reprint this important paper. Copies of the Proceedings of the Seminar are available at $US 6.50 from the CDC. References to the other contributors have been allowed to remain untouched in this paper.

From listening to the previous lectures, I have come to some conclusions. The first one is that “Man was not meant to fly”. I think that man was not meant to dive, either, after what we have heard for the last day and a half. I gave it some thought last night, early this morning and during lunch, and I have concluded that perhaps we should adopt Dick Longs’ “System Approach”. Man is very poorly adapted to diving, but women are apparently much better adapted to diving. It is my feeling that those of us here who are involved in professional diving should simply supervise and leave the diving to women. No, I’m serious. Women have a much better distribution of subcutaneous fat and also those areas have been demonstrated as high heat loss areas - the hands, the head and the feet - are proportionately smaller. Also the genital region doesn’t have as much surface area, so maybe this is really the answer to some of our questions. It should make life happier on the rigs and barges, at any rate, and that allows both a physiological and an anthropomorphic reason to justify my “Systems Approach”.

During this session we want to focus our attention on practical problems and find ways to apply known physiological principles. It will be our responsibility to apply these facts to diving operations in order to save lives. We also want to stimulate the imaginations of the divers in the field. They may see opportunities which researchers or physicians or engineers are not aware of, for the application of scientific principles to solve practical problems.

I want to take the speaker’s prerogative, before I get into “nuts and bolts”, and address one of my pet subjects: the preventive aspect of diving medicine. One of my interests has always been preventive medicine, and one of the reasons I have chosen to remain in diving medicine is that I feel it is an area where preventive medicine and preventive engineering can be applied with greater benefits than other fields that I am familiar with today. In diving and aviation, the preventive medical aspects have certain parallels. Most people today, even many pilots, do not realize how much physicians and engineers worked together in the late 1930s and throughout World War II to solve an awful lot of problems in aviation similar to the ones that we now face in diving. It was a genuine co-operation and exchange between these two professions.

One of my concerns is environmental control and, in my opinion, environmental control in the diving industry today is inadequate. There are lots of different systems, and there has been a lack of communication among the people who design the various systems. Every time a diving company wants an environmental control system, it decides to design its own, so we end up with a hodge-podge of things. For instance, within our own company, we had sixteen environmental control units on sixteen different rigs, all inoperable for sixteen different reasons during the month of August.

Another point, which Paul Webb touched on earlier in this meeting, is the fact that we spend thousands and thousands of dollars, and incalculable amounts of pounds and guineas and cents, trying to send a man down into this hostile environment to perform work which demands two unique human qualities: judgment and psychomotor skills. We continually compromise both of these qualities, man’s judgment and his psychomotor skill, by either overheating him or underheating him. You have seen physiological evidence that, whether too hot or too cold, the first thing affected is the brain. Such men cannot make good judgments and they cannot perform well. I just reviewed the design of a life support system for a device that is supposed to enable men to work effectively at 3000 feet. As proposed, this life support system would have placed the men inside the device into a situation of severe oxygen toxicity well before the calculated duration of the life support system had been exceeded. This kind of thing just goes on over and over again.

But let me back my first point about prevention. To prevent accidents, which is fundamentally why most of us are here, we must maintain the man’s cerebration, his judgment and his manual dexterity. Many, if not most, accidents begin because of judgment errors. Perhaps the most common factor compromising judgment in diving operations is chronic fatigue. I want to cite an example which I saw recently on a rig which shows how the lack of a systems approach can cause problems years later. This happened aboard a drilling vessel in the Adriatic off the coast of Yugoslavia. During the design of the diving system, it was assumed by the people who were putting it together that “Gee, it’s going to the Mediterranean and that’s a nice sunny place.” We have all seen the travel brochures. Constructing a control shack - a control van, and having air-conditioned or heated, was just ignored entirely. In fact, it was brought up at the time, but management said, “Man, you guys are going over to the Mediterranean. We don’t have that stuff in the Gulf of Mexico and you don’t need it there.” We had always gotten by without them before, and so away it went.

Well, if they had asked me, I probably would have said the same thing, if I had been in the same situation of allocating dollars and making those kind of decisions. But in fact, the Adriatic off Yugoslavia in November is subject to 70 and 80 knot winds, and temperatures of freezing and slightly above. I don’t recall the wind chill factor on that, but it is pretty cold. To expect people to stand saturation decompression watches outdoors, or wrapped up in a jury-rigged tent, is asking a hell of a lot of them. To put a man on watch in one of the most dangerous situations possible, one of extreme boredom in watching gauges where a slight deviation of one could be significant or foretell a disaster, where he is expected to make quick and accurate judgements because incorrect hasty judgements can be fatal - and then expect him to be able to manipulate a series of valves with half frozen fingers - this is extremely poor planning. We got trough that all right, but only by standing short watches. It was just too cold to stay alert and awake for longer periods. Dutchy and I happened to be there to add two more people to the crew, but in the usual situation there might have been only two people available, three at the most, to man those watches. So, in addition to exposure factors, you have the fatigue factors that mount up over the days to give you an intolerable situation from the standpoint of potential accidents.

Nobody in the diving industry is quite ready to accept this yet, but I think we are going to have to look at crew size. You might have to pay more at the gas pump as a result, but I think that, in general, we operate with too small a crew, particularly for longer duration saturation dives. I think someone who has expertise in this area should look into the situation and define optimal watch-standing periods. Now, that is not a terribly esoteric physiological problem, but there has been some work done on it by NASA. A spacecraft would have its crew in a similar situation, sitting on one position and watching gauGes. They say that the maximum time that you can expect a man to be able to perform optimally under such cIrcumstances IS about four hours. HowevEr, in the diving industry, twelve hours is the common watch period. Simple little things like that, I think, can be highly significant.

I was a bit angry at Glen for starting off by talking about how it is better for divers to be a little chubby, because one of the problems that I have is trying to promote physical fitness among commercial divers. In general, they are among the most unfit people in industry, and understandably so because, at least in rig diving, there are hours and hours of boredom and inactivity punctuated by rare interludes of panic. They sit out there for two weeks without diving and are subjected to a very boring situation and denied most of the niceties of life. The only escape is to go to the galley every six hours, and eat too much. We tried an experiment in the North Sea of putting bicycle ergometers on rigs, and offered rewards to the crew that pedalled the most miles during a two week tour of duty. Things like that are worth trying because poor physical condition decreases tolerance to the type of things we are here to talk about: hypothermia and hyperthermia.

Adequate nutrition and hydration certainly are significant as well, not only simply in the long term, either - they are damn significant in the short term as well. No commercial diver, I imagine, has ever come back from a dive without being in a relatively dehydrated condition. No effort is made to see if that man is at least adequately hydrated before the dive. One thing which I have advocated for years is having something to drink in the bell so that, when the diver gets back inside, he can drink water, or lemon squash, etc., preferably something with electrolytes and all those good things in it. These things can make a difference and can influence decompression. It can influence your resistance to heat stress and cold stress that we have talked about.

We have talked about the types of build, and to look for symptoms earlier as far as the hypothermia is concerned. One of the problems that still plagues us is the inside tender of the bell; he is the one who is getting decompression sickness more often than the diver who is out in the water. There are several speculations as to why. It could be that he is colder inside the bell than the diver is outside. Also it could be that they neglect running their scrubbers because of interference with communications. Simple operational things like this do matter. In general, we are too sloppy in our operations and we need to improve. A diving company should be able to say: “OK, we have taken a systems approach, and we have looked at it, and we think there are several little things that we can do that might significantly influence our accident rate, and by God, all you guys in this area for the next six months are going to do it this way. Period. And we’re going to gather the data on it and see whether it makes any difference”. Maybe the guys in another area don’t even know about the “experiment”, but that kind of thing needs to be done. We have talked about laboratory experiments but this is an experiment that can be done offshore. This is a very simple experiment. It is an operational experiment.

There is one more area, which we did not quite touch upon, which concerns nutrition and preparation for a dive. I have seen one near casualty that I think I can attribute to this, and I just want to bring it up to warn others. People ask about alcohol. We know what it can do in short term. One of the things it can do in the long term, however, is cause hypoglycaemia. In addition to hypothermia, and quite often I think in conjunction with hyperthermia, a contributory cause of accidents has been alcohol induced hypoglycaemia. Divers by tradition are spree-drinkers. They do not drink on the rig, but when they go ashore they often stay in a mild degree of inebriation for about two weeks. Occasionally in the North Sea they arrive at the helicopter pad and have to be helped onboard the helicopter. I have known several occasions where they arrived on the rig and were immediately asked to dive, have admitted later that they were actually drunk when they did. Now, that is one situation which is bad enough to begin with. What is worse is a guy who is a little more conscientious, who says, “Well, I’ve been having a right good run ashore, and I’ve got to go offshore about three days from now, so I’m going to taper off”. Well, he does!

This is a perfect situation for reactive hypoglycaemia. This man doesn’t even have to be an alcoholic. He just has to have been drinking a fair amount over a week. If he has been ashore longer, that just makes it more likely to happen. This is something the FAA recognized years ago. It happens to doctors and lawyers who make a lot of money and spend it on airplanes. You know, they have three drinks, three cocktails at night for a month, and then they get two weeks off and they decide to fly to Catalina or the Grand Cayman or somewhere in instrument weather conditions, and the second day out they start to get a little shaky and they are sweating. They might end up in a thunder storm, and under the stress of the situation they become hypoglycaemic, pass out, and then crash. This is a result of something that happened days earlier. Let me warn you that divers set themselves up for this particular situation every crew change - either the situation where the diver has stopped all alcohol intake three days before, or where he stops when he arrives out on the rig drunk and is called to dive. Alcohol and exercise really aggravate hypothermia.

We had a mysterious occurrence which turned out to be a near accident, where a diver was doing a 400 foot dive off Vietnam. He came back to the bell after the dive and was getting up into the bell when he just lost consciousness. There was never an adequate explanation for it, although, when he got back to Singapore, he had EEGs and a really good neurological workup. When I got the history of it, I found he had taken three days to get from Singapore to the rig. It probably was not his fault- he had to go on about three different short haul airplanes and never checked into a hotel, although he did spend the night in Saigon before going offshore. This man’s entire diet probably consisted of alcohol in one form or another for three days, and within an hour and a half after arriving on board the rig he was locking out at 450 feet. And, gentlemen, that is not a good situation for several non- medical reasons. But for sound medical reasons as well, it is very dangerous. Be advised, and beware of similar situations.

To sum up this section of my talk, I propose that every diving system that requires prolonged decompression watches, say, more than eight hours, should have a control van. The van should have an environmental control system as well as the DDC, which means it should be airconditioned or heated so that the man inside on watch stays awake and comfortable, mentally and physically prepared to make the necessary decisions. Someone should consider a look at our watch schedules in the light of safety and efficiency, and be aware of the point I brought up about diving and alcohol, and the post hypoglycaemia.

I want to tell you a sea story. It is a true one and most of the people involved with diving will recognize a lot of the things that went wrong and why. I want to tell you a bit about the Johnson-Sea-Link submarine entrapment, tell you some of the things that may seem peripheral, but really are significant to the overall situation. I was there, and two of my friends died in the submarine, and I know the background quite well. I want to tell you some of the errors that we made. I share the responsibility for becoming lackadaisical in our attitude toward submarine operations. We had been operating for nearly a month very successfully, training a team in shallow water. We had gotten down to a smooth operation, had gotten into a bad habit of allowing joy rides in the submarine as well. It was the seventh dive on that wreck when we got entangled. The fatigue factor was there, I know from personal experience. Submarine operations generally require an 18 hour day because you are up at dawn and charging batteries and running two or three missions, then there is always a mechanical problem to correct. By the end of the day everybody sticks together and works on it until it is over. The fatigue had been allowed to accumulate. In fact before that dive we had been up until 2:00 in the morning. Nobody knows and nobody can quantify how much that applies to things.

The original dive plan did not include divers in the after compartment. It was a mission to go down and pick up fish traps, and afterward we planned to go down and do a lock-out dive on the wreck. We had done one lock-out at that depth. We knew it was cold, but we relied upon the diver’s judgement, and we did a lock-out at 350 feet in bathing suits. We were going to wear wet suits the next time, even though we knew we would not get much additional protection. It was colder than we had expected. We had actually measured the temperature on the previous day for scientific purposes, with a recording device that we had attached to the submarine, and I am ashamed to admit now that we were so unconcerned that we didn’t even look at it. We knew it was somewhere around 55° to 60°F.

During the pre-dive briefing, we decided, “Well, a couple of guys want to go along on an observation dive. No lock-out. Just ride along for familiarization with the sub”. Clayton was only there for the weekend. It was a last minute decision, and they walked back and got into the submarine wearing sport shirts and short pants and tennis shoes. It was stupid for us to allow that, but we had done it so many times and gotten away with it, just as all of you have in various diving operations, that we simply were not concerned.

There was some lack of foresight in design. The acrylic sphere in the forepart of the submarine was an excellent insulator. In fact, I nearly died of hyperthermia in it in another episode, where I got trapped on the surface and couldn’t be picked up after the air-conditioner failed, but that’s another story. Aluminium, even if it is very thick, is a very good conductor. That was something we had really not thought about. The after compartment - the diver compartment - should have been insulated, but we had never felt any discomfort before because it had usually been operated at one atmosphere or pressurized only with air.

We all knew of the loss of efficiency of sodasorb scrubbers as temperature decreases, but we really had not thought a lot about the consequences. We knew the sea temperature was 55° to 60°F, and we knew we had plenty of sodasorb to last the duration of the dive we had planned. The suggestion had been made that we should use lithium hydroxide or at least carry lithium hydroxide for emergencies, but it had been turned down on the grounds that it is too expensive. It costs $7.00 a pound versus 65¢ for sodasorb. You know that is an easy kind of situation to get into when making those kinds of decisions. Lithium hydroxide costs several times more, and we had always used sodasorb. Lithium hydroxide is toxic, as well. Let’s not bother. The fact is that, if you look at the overall cost of a diving operation and count the capital investment and the depreciation on it and things of that sort, the difference between sodasorb and lithium hydroxide in any situation where you may be exposed to cold is simply insignificant. So you ought to consider having lithium hydroxide available for an emergency entrapment situation. I am sure you are all aware that the scrubbing characteristics of lithium hydroxide are very good. Between 70° and 35°F the efficiency falls off very little, whereas sodasorb falls off to practically nothing at 35°F. These were all things we could have done earlier.

We had thought about the possibility of entrapment, and, in previous operations with diving bells, I had always insisted on having bolt cutters on board when I was in the bell. But we had not done it; we had promised to do it the next time we were in port.

Little things like that creep up on you you know. One of my pet tenets of philosophy is the well known “Murphy’s Law” and I think at sea it applies one hundred percent of the time: if anything can go wrong, it will go wrong. And if there is a possible chain of bad events, it probably will occur in that chain and not just one at a time.

Well, the submarine went down on a routine mission, tried to pick up the fish traps, got entangled in a wire from a radar target on the ship, and that is where “Murphy’s Law” came into play - the moment that the submarine became entangled.

The submarine had three motors aft, mounted vertically. The pilot had a red light on his control board indicating a top motor failure. The submarine was hung up and the pilot knew he had fouled a wire. He could look back and see the wire, but he could not quite see where it was going. And just then, practically simultaneously, the motor goes out. So everybody assumed that the cable was fouled in the propeller. We found out later that the wire was not in the propeller. It was fouled in a snap hook, a snap hook on the starboard side of the submarine. The hook didn’t even need to be there. At one time there was a necessity for that snap hook, but when that necessity ceased, since it was a potential hazard, that snap hook should have been removed. But that is the overall thinking I am trying to stress. It needs to be applied to these kinds of systems. From that point on, everything went downhill.

The men in the forward compartment, even though their scrubber motor failed, were able to improvise a scrubber. They took their shirts off and lay sodasorb onto them to fashion emergency scrubbers which performed adequately for the entire 36 hours or so that they were trapped. They had acrylic to insulate them from the cold. The people in the after compartment, who were in an air atmosphere initially, started to get very cold, they started getting CO_2 buildup. As the CO_2 buildup became more and more severe, the only alternative was to go onto the BIBS. One of the things we had neglected to really think about operationally was, “What happens when you go on a BIB system when you’re at 350 feet and you don’t have an overboard dump?” Well, the exhalation starts to pressurize the compartment. It is all very easy to see after the accident, and perhaps someone else has thought of it, but I had not really thought about it up to that time. Within an hour and a half or so, they had pressurized by exhalation alone to over 80 FSW. Nearly 100 FSE, we thought. It turned out to be 100 feet because the gauge, the Caisson gauge inside, had gotten out of calibration. At that point, we switched the BIBS to heliox which made the situation worse. We switched the BIBS to helium to protect the people from nitrogen narcosis and to reduce decompression time when the rescue vessel arrived.

Well, the colder they got, the faster they breathed. And the faster they breathed, the more they pressurized the compartment. Within about four hours the bottom hatch open equalized at 350 feet. They were trapped in a predominantly heliox atmosphere in shorts, tennis shoes and shirt, and they were really cold, really suffering all this time. Their judgment probably was starting to be affected, because at that point one rescue attempt had been made and had failed, and I estimated from O_2 partial pressure that they had from 45 minutes to maybe an hour and a half of consciousness left, but probably not more than 30 minutes of effective operational time. I suggested to Jock Menzies that they lock-out and try to free the submarine and we discussed this back and forth for a while. There was no way we could force them to get out, and they elected not to get out because they were under the assumption that there was a wire in the propeller and they did not have the tools and doubted they would be able to free it. They felt that their functional decrement was too great. They had the diving gear to do it, which was something that was misrepresented in the reports. They could have made a lock-out. That was the real tragedy of the situation in retrospect. There was one wire hooked under the snap hook, a hook with a spring mouse on it. Had they known, I still believe that, at that point, they had sufficient and physical power left to do a breath hold dive from the hatch up to that wire and, with one hand, press in that spring- loaded mouse and pull that wire down and then get back into the submarine. But that is not the way it turned out.

So. Let’s review one more time some of the things we neglected. We did not review our operation in a systematic manner. We were too optimistic. We did not anticipate all the possible bad things that could happen. Well, unless you do those things you are going to get caught by “Murphy’s Law”.

Hypothermia

To introduce the immediate management of hypothermia in a friendly spirit of disagreement, I will jump right in where Larry Raymond left off yesterday, saying “Well, it’s not really an emergency anyway. Get the guy back into the bell, bring him up on deck and transfer him into the DDC and you’ve got plenty of time to rewarm”. Based on my experience, I should say first of all, you will have a lot of trouble getting the diver into the bell. Secondly, once you get him into the bell, you are going to have trouble closing the hatch; the “O” ring probably will drop out, better have a spare. And in the third place, after you have surmounted all these obstacles and gotten the diver into the bell, the winch will probably fall. So, what I want to focus on are the ways to treat these casualties and others that require immediate treatment. In my feeling, acute onset hypothermia, of the degree that is possible at 1,000 feet breathing helium, is a real emergency that requires immediate treatment if it is available. I will take that stance for the sake of the discussion.

Now, what should we do? The first thing to do is to remove the victim from the cold environment. You should at least remove him from the water. That is a colder environment than in the bell. A lot of the bells I have seen are not even adequately equipped to remove a diver from the water if he is unconscious, and unable to assist. First of all, you've got to have a harness. You've got to have a harness that picks him up in a position so that he is able to breathe, assuming that he is still able to breathe, or, if he is not able to breathe, a harness that assures an open and accessible airway so that you can breathe for him. I would be willing to wager that something like 60 percent of your harnesses will not allow for the fact that you are going to pick the diver up by a simple chest harness with a pick up point in the back, and the diver's head will be held forward and down by a heavy helmet or mask in such a manner that his airway is shut off automatically. So the practical solution to this problem is to devise a harness that picks up from some point on the front of the chest.

You've got to have a harness on the diver, you've got to have the pick up point in the right place, and you've got to have a winch to lift him. We have rigged tackles, all different sorts, and you end up with lines running everywhere, all tangled up, and the blocks capsize. It really does not work. It works in the dry, it works in the drills, but "Murphy's Law" applies here, too, and in a genuine emergency it will fail. A very nice device does exist: I don't even know the trade name of it, but Dick Long probably sells it. It really works and it is one of these aircraft cargo winches with a ratchet drum. But you don't take rope and put it on the drum with the ratchet, that's too slow. You run the rope through it for four turns, so that you have a tail on it that you can pull to get the diver up and into the bell hatchway. At that point you can crank the ratchet to help pull him up into the bell.

The second thing, if you do not have a winch or if the one you have does not work, is to get him inside the bell by flooding. Practice it. Have your scrubber out of the way so that you can flood the bell halfway, and then float the diver through the hatch. It really works well when all else fails.

Once you get him in there, assume the worse possible situation. His heating system probably has failed. He is at 1,000 feet and both his suit and his respiratory gas heating systems have failed - despite the fact that you have redundancy through the entire system, ie., you have two pumps and two heaters or at least an alternate source of heat.

One should be enough, but Dick Long has been granted immunity from "Murphy's Law" so you can just get by with one of his, but we try to have one Dick Long unit and one alternate system for heating water, just in case.

Open- circuit hot water suits are the greatest thing that has come along, but I would like to see some more emphasis and ingenuity devoted to closed-circuit hot water suits, because they can continue to work inside the bell. The bell tender is the guy who is now getting the cold exposure. We could eliminate some of the variables from our decompression and other things by having both divers at the same temperature, both the bell tender and the diver, and they could even stay at a constant temperature during the adiabatic cooling during decompression. When you consider lock-out submersibles, I do not see any practical engineering possibilities other than closed-circuit suits. We would welcome them from anyone at a reasonable price.

Now remember if you have a total hot water failure, you have about 20 minutes before the body core temperature starts to fall off rapidly, so you have time to get back into the bell and get things squared away. But you must also remember that respiratory heat loss begins immediately, so if you do end up with a closed-circuit suit and there is a failure in the water, don't say, "Well, I've got to finish the job. And they told me I had 20 minutes before my core temperature starts to drop because I've got a dry suit on". Don't do it, man! While you have the chance, get back in the bell before you start to be affected by respiratory heat loss.

OK, we've got the diver back in the bell. We have overcome all these simple seamanship problems, and he is back in there and the hatch is closed and there is an "0" ring under it and you've got the hose taken care of - cut it away, let it go so it won't be in your way. You don't know the core temperature because we don't have monitoring systems yet.

The patient is unresponsive; he doesn't have any detectable pulse. You are looking for a carotid pulse which, if you have a backlift harness, you are not going to be able to reach. What are you going to do? Here is a cookbook approach: first thing you ought to do with the diver, when you get him up into the bell and his head out of water, is to give him immediate mouth-to-mouth resuscitation. That is the warmest gas you have around at the moment and he is not breathing very well, so don't hesitate. As soon as you get him out of the water, breathe for him and then proceed with all these other details, and every chance you get, stop and give him a few breaths because his brain cells are dying all the time.

OK, let's look. What assets do you have, now that you have the diver in the bell? If you had to flood the bell, you now blow it dry. Let's hope you have a situation that will allow you to blow it dry. What do you have on hand that you can use to revive him? Maybe the hot water is back on line. Probably, if you had a failure, it was somewhere topside and by now perhaps it is repaired. You should have your system manifolded so that you can now use your hot water suit, open-circuit or closed-circuit, in the bell. We discussed controversies about warming the extremities, etc. You don't have a whole lot of choice in the bell because they are very small, and for you to get into a position where you are able to perform cardio-pulmonary resuscitation, you are going to have to have him lying down on top of the inner hatch and probably on top of a coil of hose. You are going to have to have his legs and arms out of the way and that probably means throwing a hitch around his ankles and trussing him up somewhere so that you can get to him. You will be rewarming him in almost the position described for use in a tub, ie., keeping the extremities out and elevated. But frankly, it doesn't really make a damn bit of difference. I would not worry about the acidosis; I would not worry about the blood in the extremities; I would try to get hot water going over him, because the alternative in this circumstance is almost invariably death, and almost anything you do is going to be correct. It is going to help him. I hope that the hot gas method is going to be a lifesaver in this situation, although I admit that more work needs to be done and more and more measurements made. I hope that somebody will start making them soon. But you have the apparatus to administer hot gas; you have a diving helmet, or a mask with a heat exchanger, and your heat is back on line, so start giving him hot gas again. You want warm gas to go over his head, because 40 percent of the heat loss can occur from the head. This is exclusive of respiratory loss, which is the main thing we are concerned with in a hyperbaric situation. Take advantage of any avenue to warm the victim, and if you have a helmet, put it on him. You do not have to fasten it down, but just put it on him loosely so that you have a constant flow of warm breathing mixture over the victim’s head, as well as into his lungs.

Well, what are the liabilities in this situation? You are probably at least a half an hour away from that DDC, even in the best operational situations. I am talking about after you have gotten the diver into the bell, gotten a seal, left bottom, passed through the interface, gone through the problems of transfer, etc. Now, suppose you have a total heat system failure, and the hot water does not come back on line? This is where I would think that central rewarming is going to be the most valuable emergency device, beside the well-trained diver, that we can have in the bell. I do not think a device exists yet in any respectable form. Studies need to be done to see if any damage is done. The two people who have done work with central rewarming are Lloyd in Scotland and the people in Vancouver.

The data from Vancouver does show the after drop in core temperature with central rewarming. They did not use the same device that Lloyd did. They were cooling the subjects in sea water, and they had them out on a ship where they had a tub to put them in, with a respiratory rewarming device. These subjects had to climb up the side of the vessel when they got down to 34° or 35°F $^{\text{rectal temperature}}$. They climbed out of the water by themselves and walked across the deck and got into the tub and began to use the central rewarming device. It is possible that the difference in the data on the afterdrop could occur from their exertion and movement in climbing up and going across the deck.

We have heard Dr Raymond talk about the disadvantages and the possible danger, so bear them in mind and don’t go running out and jury-rig these things and use them unadvisedly. We really require further research on it. However, I would be willing to say, given Lloyd’s cases in Scotland plus the work in British Columbia, that if you have no other source for rewarming a diving casualty outside a bell, the tub of warm water is an acceptable emergency form of rewarming in this acute situation and I would use it. But I may regret these words one day.

Dr Lloyd found no after drop in core temperature, so you do not have the rewarming collapse. He feels like this form of rewarming warms the brain earlier than putting someone in a tub and running hot water over him. It has not been proven in humans, that I know of, but there have been dog experiments in Germany which claim that the vasomotor centre in medulla ceases to function at about 81°F. Cold-triggered impulses from the skin may keep the blood pressure elevated in an acute hyperthermia situation. There is a danger here of dumping somebody into a tub who has been through all this cold and hydrostatic pressure effect, and who now has an inadequate circulatory volume. These investigators feel that the central rewarming might heat the brain first and wake up the vasomotor centre, thus allowing the body to get a little edge on the situation by peripheral vasoconstriction. This could avoid, or at least help offset, the hypotension that may occur if a hypothermic person who is volume depleted is rewarmed peripherally instead of centrally.

Are you familiar with Lloyd's device? It is different, I think, from the Canadian one. The mountain rescue teams in Scotland use it. It is just a simple canister. This is in cross- section. It is called a watters canister, a to and fro anaesthesia circuit, with an oral nasal mask. There is a CO_2 cartridge which BOC produces to pressurize beer kegs. The canister is filled with sodasorb, and you fire the CO_2 cartridge off and the exothermic reaction of this CO_2 reacting with the sodasorb jacks up the canister temperatures to around 60°C. They were so incautious in regard to temperatures that they did not measure them initially, but they found that this is within the temperature range which the hand can tolerate without much stress. So they just fire off a couple of CO_2 cartridges and, if they're out there up on the mountain top and they still don't feel the canister is warm, they fire off another one. They already have the victim breathing oxygen anyway, and the highest the CO_2 level reaches in a mask is about 5 percent.

They continue on with this, and if the thing starts to get cool by touch, they fire off another cartridge. It is a pretty simple little device. We already have the makings of that in the diving bell. We have scrubbers in there, and some of the more advanced companies have devices that you can put on the scrubber, so that you can breathe on it in a passive mode. All you have to do now is bravely add some little CO_2 cartridges to your system. You would not want to use pure oxygen, of course.

I understand that the US Army has one of Dr Lloyd's devices at Natic now, and they are running some tests on it. If I can get hold of one, I want to run some tests at Duke on pigs. We will get a pathologist to take a look and see what we are doing. Lloyd did report, in his first series of eleven patients, that two cases presented laryngeal problems. I think one case was laryngeal oedema and one case of "scalding of the trachea". That is kind of imprecise, and I don't know how scalded it was or just what they meant, but I suppose they got that conclusion on autopsy.

I will read something to you of what Lloyd says in his paper. The reference is Lloyd, et al. Conrad and Walker. It is called, "Accidental Hypothermia - Apparatus for Central Rewarming as a First Aid Measure," *Scottish Medical Journal*, 17:83.

A general summary is that heat should be applied centrally to warm the body selectively. The equipment should be compact and lightweight to enable it to be carried by rescue teams. That means it has to be small if we are going to allow it to be carried in a diving bell, because it is going to take up space. We are not so concerned about the weight, but space is at a premium and we don't want anything in there that we hope we will never have to use. It should be simple to use as well as safe, since people that are using it are likely to be non- medical.

That is all I have to say now on the subject of hypothermia - no, wait. I have one more thing that I forgot. Let us suppose the winch did not fall this time, and we did get the diver all the way back up into the DDC. Now we have a choice of using a hot water suit in the outer lock, or simply filling up the entrance lock part way with hot water.

If this had been a routine cold water dive, the diver probably is going to be relatively dehydrated, and despite the low metabolism in the periphery, he probably is going to have some mildly acidotic blood trapped in his extremities. He is going to be sort of anaesthetized from the cold, and this is an excellent opportunity for the medic to get in there and practice starting an IV of warm lactated Ringer's solution, 1,000 millilitres. One thousand millilitres of warmed (which means body temperature or slightly above) lactated Ringer's does not mean a great deal in relation to the whole blood volume, but it becomes a more significant percentage if you consider that this man is still in acute hypothermic state and completely vasoconstricted in his legs and arms. What you are doing is trying to dump one litre into the central volume. It may not be highly significant, but it serves two functions: it adds a few calories, and it allows access to his circulation. In mountain rescue situations, they have to consider this problem all the time because, when they start their IV's, they often find them frozen. They are trying to resuscitate a hypothermia victim and they are giving him extremely cold intravenous infusion. I think we ought to try to give our diving casualties warm infusions, and I think there are enough data that we can assume a relative dehydration that will allow the safe administration of at least 1,000 millilitres of lactated Ringer's solution on a purely empirical basis. You will not have any laboratory data or anything else until you get the diver to the point where you can start to monitor his urinary outputs, and listen to his chest, and be aware of things so you do not overhydrate him. That is where I was going to stop on the hypothermia side. While I do not really welcome it, those who have strong criticism of the intravenous recommendations are invited to speak forth now and later.

I think the standard things that come in the little handbooks about treating hypothermia anywhere are applicable if you have gotten the diver through the decompression phase.

Remember, when you look at the fact, you say that is a rather insignificant amount of heat to add, but let us go back to the principle of removing him from the hostile environment. He is still in a cold bell, and if he is breathing at all, he is still going through a decreasing but very real respiratory heat loss. So, assuming you are still with him, you can at least slow down his rate of loss by eliminating that factor of respiratory heat loss. Beyond that, I am open to suggestions.

Hyperthermia

Now I am going to talk about hyperthermia. The other speakers have covered the physiological aspects of hyperthermia and heat stroke very well. I have just searched the literature, and Dr Webb has sent me all kinds of good things over the past few months, but on my way out here on the plane I discovered in the March 1976 issue of *Aviation Space and Environmental Medicine*, this article: "Heatstroke: A Review," by Civelete, Lancaster and Bannon. This was an update of an earlier article by the same authors. It is about 17 pages long and quotes 270 references. So I really wasted a lot of time last week. These authors seem to feel, as I do, that the distinction between heat cramps, heat exhaustion, and heat stroke is over emphasized. Maybe it is a philosophical point, but I think they are all in a continuum of a syndrome that is developing, and they should not be looked upon as single clinical entities. Once you start to see the signs and symptoms of the most innocuous one, you should be advised that the more serious ones may well be on their way, and you should take appropriate action. Again, to add to what someone else said earlier, a heat exhaustion casualty is a candidate for evacuation from the rig, as far as I am concerned, because he needs to go ashore for medical evaluation. A heat stroke victim, no matter how mild, needs to get off that rig and be hospitalized for observation, because his thermo-regulatory system has been compromised. You do not want a recurrence either on your hands or on your conscience. Besides, he may have malaria masquerading as heatstroke, so get him off the rig.

Dr Webb discussed the accident on the Waage where two people died, and I am going to cover that in a little more detail because several things have been published which do not portray the situation as it actually happened. I am going to read through an interim report which I wrote after the investigation of this incident. Please remember this is an interim report, not a final one. It is an impression we had shortly after the accident, and after gathering considerable data through interviews with everyone involved, including some of the people that were observers from the crew on the rig.

As I have said, very few diving accidents are the result of a single factor. In this situation several factors which occurred previous to the incident contributed to the death of these two people. One of these factors was the operational practice of monitoring the bell (Submersible Decompression Chamber) depth by means of a master gauge, which is a common operational practice, not only in Oceaneering but in other companies as well. I do not necessarily condemn it, although it is not the way I would do it. I feel that every pressure vessel in a system should have its own independent pressure gauge, and this one did actually have that, but because some gauges are better than others, the supervisor had adopted the practice of using the master Heise gauge to track bell depth in the water.

The focus in the North Sea had been on hypothermia. Everybody there worried about hypothermia. We have heating coils and insulation and the like, and the practice had become routine on those types of dives to preheat the DDC (Deck Decompression Chamber). When they knew that they were going to make a dive, they turned on the steam coils underneath the deck plates in the main lock.

Ordinarily, after arriving on the deck, the chilled divers transferred under pressure from the bell into the entrance lock, and undressed. The entrance lock was not heated. The diver stepped into the main lock and warmed up. He could tolerate this for a time, and meanwhile some heat exchange was going on. But if it was too hot, if he was uncomfortable, all he had to do was to step back through the hatch and return to the entrance lock. He could cool off for a while, then re-enter the main lock. Meanwhile the system is equilibrating. Besides, this is a crude environmental control unit for dehumidification. With cold steel in the entrance lock, and all this hot steel in the main lock in a heliox atmosphere that is saturated with water vapour, a convective flow is created which precipitates water out against the cold steel of the entrance lock.

They were a little delayed in beginning the dive this time (they had a longer observation dive than usual) and the temperature climbed to over 105°F in the DDC. I do not know exactly how hot, but at least 115° to 120°F in the last time anyone looked. That would not have been significant if all systems had retained operational as they had been in the past. It would have meant that the divers spent a shorter time in the DDC before returning back to the entrance lock to cool off, and that equilibration between these two compartments might take a bit longer.

The bell arrived on deck and they prepared to transfer under pressure. On the first attempt, there was a leak at the mating flange. That is a common occurrence. So they pulled the bell back and over-hauled the seal and brought it back together, and this time there was no leak, or maybe just a slight leak at the mating flange. It was nothing to be alarmed about.

The diver transferred into the entrance lock. One of the divers was instructed to re-enter the bell and bring the gear out and transfer it as well, because they wanted to pull the bell away and clean it up for the next dive. At this point the diving supervisor, alone in the control van, noticed a drop on his master Heise gauge which ordinarily reads the main lock because it is the biggest compartment. He saw the pressure begin to drop and he thought, “Well, we’ve got a leak”. He instructed the divers to get out of the bell, into the entrance lock, and close the hatch because he thought that gas was escaping through the mating flange.

The divers entered the lock, closed the hatch and leaned against it to effect a seal. But closing the hatch did not seem to cause much difference in the leak rate. So the supervisor said to the divers, “Well, don’t panic. Get in the main lock and shut the hatch to the entrance lock”. So they transferred into the main lock and shut the hatch. One diver said, “Hey, it’s kind of hot in here”. But nothing seemed unusual. And the supervisor replied, “Don’t worry. We’ll take care of that in a minute”.

In order to get a seal on the main lock-entrance lock hatch, the supervisor bled down the entrance lock. This is the normal thing to do if you want to ensure a seal. And if you think you have a leak elsewhere in the system, you want to make sure you get a seal. He opened up the exhaust valve a little bit and he bled pressure off. I do not know how much.

At that point, the divers were trapped in the main lock. The supervisor was watching the pressure drop in the bell while presuming that the gauge represented pressure in the main lock. The gauge had been representing the pressure drop over the whole system until the main lock-entrance lock hatch had sealed. After that, it indicated the pressure in only the entrance lock-bell complex. Since the same leak was now draining a significantly smaller volume, the gauge indicated a greater leak rate than previously, about six times the rate. The volume had been decreased to one-sixty so the rate of indicated leak on the gauge went up six times.

There are very few emergencies in commercial diving operations in which you cannot just stop and analyze the situation and figure it out, but, when you see a six-fold increase in a gas leakage rate in a manned compartment, and you do not know where the leak is coming from, that is one situation in which you want to react quickly. And there is only one thing to do: start pressurizing and make up for that gas loss, and that is what the supervisor did. He pressurized.

They were at 510 FSW and he pressurized to 650 FSW. The divers could sense being pressurized and they tried to tell the supervisor, but he did not understand. His sensory system was overloaded. He was watching gauges and adding helium while the crew on deck scurried about looking for a leak which did not exist. And then suddenly he looked up, switched gauges, and realized what he had done.

All the while, the divers in the main lock had been trying to indicate that they were being compressed. They were not unconscious. I am sure they felt an intense adiabatic heat load in addition to the 110° or 120°, but it probably did not exceed the short term heat loads that people can accept even considering the respiratory heat load factors. The divers in the main lock opened the equalization valve to the entrance lock which started reducing the pressure in the main lock, while the supervisor responded by repressurizing the entrance lock to make sure that they did not come up too far. The main lock and the entrance lock equalized at 504 FSW. This was within the safe upward excursion distance and they had no decompression problems.

Our policy for the past two years has been to tape-record the conversation of all divers. We do this for two reasons: one, to improve communications discipline by reviewing the tapes after the dive; and two, so that we might have a record of the sequence of events in case anything abnormal occurs. This particular dive had been taped up to the point of transfer under pressure, but after starting to transfer they felt there was no longer any reason to tape the conversation. So we do not know the exact time frame in which these events took place.

The divers appeared to act irrationally. One man left the DDC and one got on the bunk and they said some words to the supervisor and then they started holding their heads and they were noticed to be sweating profusely. They went rapidly through the entire clinical spectrum of acute heat stroke, culminating in dry, red skin, sweat glands exhausted. The holding of their heads probably would indicate severe head pain. They also had some bleeding from the mouth and nose which would go along with some of the reports of clotting problems and disseminated intravascular coagulation in heat stroke.

Up to this time, no one had recognized this as a hyperthermia problem. John Boyce really deserves most of the credit for first recognizing what had occurred. We analyzed the sequence of events and felt that what we were looking at was heat stroke, hyperpyrexia, as a result of heat loading from the high temperature of the main lock. The fact that they were recompressed in hot helium probably accelerated the onset of the fatal hyperpyrexia.

The UK Department of Energy investigators did not accept that diagnosis at first, but we had an autopsy at the University of Aberdeen which confirmed our initial impression.

Let me just read part of this report as a summary:

“Commercial working divers in the waters of the North Sea are a common occurrence, and the dangers of cold-hypothermia-are well recognized. To overcome the hazards of hypothermia, hot water suits, breathing gas heaters, thermal regenerators, and diving bell/DDC heaters have been developed. With the emphasis on hypothermia in deep diving, compounded as it is by the high thermal conductivity of helium, we have tended to overlook the danger on the opposite end of the temperature scale - hyperthermia. The hazard is there, compounded again by helium’s physical properties, plus the complications introduced by high humidity and low flow velocities in the chamber micro-climate, factors which preclude the loss of body heat by evaporation and lead to heat loading with every respiration.

"Once the body temperature begins to rise, cellular metabolism increases, producing greater than normal quantities of heat. Roughly speaking, at 108°F, the rate of metabolism of the cells is doubled; at 114°F, the rate is almost quadrupled. The hypothalamus, the part of the brain acting as the body's thermostat, functions poorly if overheated, and a vicious cycle occurs: elevated temperatures cause an increased rate of metabolism, which causes increased heat production, which elevates the body temperature and further damages the hypothalamus. Once the body temperature exceeds 107°F to 110°F, the body's thermostat fails and the body temperature may continue to rise until death occurs unless rapid and extreme measures are taken to artificially lower the body temperature.

"Man's tolerance to elevated temperatures is directly related to his ability to remove heat from his body core by increasing blood flow to the skin surface and then lose heat by evaporation of sweat. It is only the evaporation of sweat that makes short exposures to extremely hot environments tolerable. Should the ambient water vapour pressure approach the 44 mm Hg (ie. a dew point of 36°C (97°F) value which is typically found on a man's skin while sweating, heat tolerance is drastically reduced. The partial pressure of water vapour at 120°F (the temperature at which the DDC may have reached prior to the accidental pressurization) is 88 mm Hg.

"Humidity control in the decompression chamber complex aboard the WAAGE 11 was normally accomplished by allowing the atmosphere to circulate by convection between the main chamber and the transfer chamber where the moisture condensed on the transfer chamber walls. When the divers inside the main lock closed the door to the transfer chamber to protect themselves from a suspected sudden loss of pressure in the transfer chamber-bell portion of the chamber complex, humidity control stopped.

"If the divers started to sweat at a maximum rate inside the DDC, a vapour pressure of 44 mm Hg would be reached very rapidly and practically no further skin cooling due to sweat evaporation could occur.

"A heat storage by the body of 80 kcal (320 BTU) with a rise in body temperature of 1.4°C (or 2.5°F) represents the voluntary limit in the average man. Collapse can occur at a heat storage capacity of 160 kcal (640 BTU) with a 2.8°C (or 5°F) rise in body temperature. Moderately active men will produce heat at the rate of 180-300 kcal/hour (800-1400 BTU/hour). If all this heat is retained by the body, a heat storage of 160 kcal can be reached in half an hour. If heat is being added through the lungs and skin, collapse can occur even sooner.

"A man breathing helium/oxygen at 300 feet with a ventilation rate of 1 cubic foot per minute and a gas temperature of 120°F will add heat at more than 0.5 kcal per minute. As his body temperature increases, so will his respiratory and heart rate, adding heat at ever increasing rates. This respiratory heat was retained, along with the ever increasing heat of metabolism, driving the divers toward an irreversible and fatal hyperpyrexia".

(Question): In addition to an awareness of the problem which is the first step in prevention, what are some of the actions we might consider in response to heat emergencies?

(Answer): The objective is simple: cool the victim as rapidly and efficiently as practicable. Achieving the objective depends on your own ingenuity.

Let me tell you another sea story which might point out some of the possibilities.

It just so happened that on my way back from the WAAGE 11 accident, I ran into an old friend in London who was homeward bound from a job off Dubai in the Persian Gulf. He had not heard of the accident, and he was talking about the rough job he has had out in the Persian Gulf. Their main chamber had an environmental control unit consisting solely of a tarpaulin to shield it from the direct rays of the sun. On several occasions, the main chamber had been occupied when my friend arrived on deck for his surface decompression in the chamber. This meant he had to use the standby chamber which did not have even a tarpaulin environmental control unit. “Man”, he said, “it was really hot in there. I just got to feeling so weak and crampy. I just felt dizzy, you know, like I was going out of my head”. He said, “Particularly between my O2 periods. Get back on O2 and it really made me feel better for a while. That O2 is really good stuff. I don’t know what was the matter with me, but it happened every time. You know, I’d get off that O2 and start feeling nauseated and bad and I’d get back on it”.

Think about that. The temperature in a chamber out on deck in the Persian Gulf is probably around 120°, 130°,140°F, and the ventilation does not always meet the diving manual standards even in Oceaneering, so I began to wonder why he felt so much better when he was on oxygen.

Well, he was breathing oxygen from a high-pressure tank, and as it expanded from its compressed state, be was getting effective central cooling. Each time during the air breaks he was drifting right up to the edge of a heat problem, and by going on oxygen he was pulling himself away from it as a consequence of breathing cool gas. So I think that is one thing we can do in a heat emergency. We can breathe cool gas as long as it does not get too cold and cause excessive bronchial secretions. Remember, any time you reduce a gas from high pressure to low pressure, it cools. So you have an advantage right there, if you can work out a way to take advantage of that pressure reduction.

Or maybe you could devise a heat exchanger for the breathing gas, say, an oildrum on that side of the chamber with a bunch of copper coils in it, and a lot of ice and salt over them when you need a cold gas, or hot water when you need warm gas. It would not cost much, but of course there may be simpler and more elegant ways to do it.

There is another little device that we have found which I think might have some application. It is called a vortex tube. You can put high-pressure air in the middle, and you get hot air out one side and cold air out the other side. You can either heat or cool. Obviously, you cannot violate the laws of thermodynamics, and if you have thing operating inside the chamber, you are not going to have any overall net change. But you can control what we call the micro-climate around the man. There is an off-the-shelf device that hooks up to the vortex tube which could be useful. Foundry workers use them. Foundries have a hot room where pigs of metal are poured. Something like 35 seconds was the maximum time that the toughest guy in a Houston foundry had ever been able to stand working in that room. But they got this vortex hood, put it on, and just ran plain old compressed air through it.

Using the hood, a worker could enter the hot room and work for 20 or 30 minutes. Remember 40 percent of heat loss occurs from the head and neck not counting the respiratory tract. The vortex hood can be a very effective means of protecting the individual in a hot environment. Now someone needs to determine if it will function in a hyperbaric chamber.

For cooling a chamber in tropical areas, I would suggest putting burlap, blankets and stuff like that over it, and running the water over that, so it will increase your heat loss through evaporation.

<u>WATER INHALATIONAL ACCIDENTS</u>

Dr RV Trubuhovich
Department of Critical Care, Auckland Hospital

(This paper was first printed in the Proceedings of the Underwater and Diving Medicine Seminar, May 1976, and is reprinted by permission of the Author and the <u>New Zealand Journal of Sports Medicine</u>. It has been updated to 1978 by the Author.)

Resuscitation of the apparently drowned is not the prerogative of recent times only, the era of most effective development of cardio-pulmonary resuscitation. It was during the 18th century, particularly with the encouragement of the Royal Humane Society, that methods of resuscitation of the drowned were enthusiastically developed. The means used were often quite ingenious. Still, before the modern practice of expired-air breathing was resurrected, I suppose most members of the audience here can remember, have seen or even have taken part in those rescues which used to be reported in the newspapers as successful only after several hours heroic effort of Holger Nielsen artificial ventilation. My function today is to concentrate particularly on the sequelae to the accidental inhalation of water. That is I am concerned with not the drowned and dead, but rather the near-drowned, post-rescue; and for them, more particularly with intensive therapy for the life-threatening sequelae to the inhalation of water, than with on-the-spot emergency care.

<u>Hospital Circular Letter No 1971/82 (1971)</u>

Firstly, however, I wish to draw the attention of any New Zealand hospital doctors here to the following advice on resuscitation of the drowned sent out to all of our hospitals in 1971. I do not know if any members of the audience here had any hand in drawing up this circular letter; but I cannot see how any person actually doing the work with the critically ill near-drowned could have included so many features then out of date by 5 or 10 years. The errors arise from extrapolation of results from laboratory animals to the human (Table 1) (Miles, 1968). The undue emphasis on “Is it fresh water or is it salt water drowning?” is not warranted. And this opinion is now also being endorsed in the literature on near-drowning (Segarra, et al., 1974). The patient must be managed according to what he actually presents with at examination.

TABLE 1
NEAR-DROWNING

Feature	**in lab animal**	**Human**
Haemodilution and electrolyte disturbances	frequent	infrequent
Pulmonary oedema	often absent	common
Ventricular fibrillation	common	?
Vehicle	lab. dist. water or saline	water with particulate impurities

Miles, 1968. Brit*. Med. Jnl* 1968; III: 597-600

Pathophysiology

Both river fresh water and sea salt water can contain a large amount of particulate matter: diatoms or silt or sand and so on; but the "pure" water of a private pool is also damaging to the alveolo-capillary membranes. The essential lesion in near-drowning is consequent on the inhalation of the water plus its contents. Whether this water is fresh or salt it is so profoundly an irritant that it produces acute pulmonary injury. The essential reaction to the pulmonary injury is exudation of plasma-rich fluid into the alveoli, resulting also in blood volume depletion. We say aspiration pneumonitis is followed by pulmonary oedema and hypoxaemia. This leads to ventilatory and circulatory impairment with hypoxaemia and metabolic acidosis as the fundamental functional disturbances, resulting in respiratory and circulatory failure and perhaps neuro-logical damage(Figure 1).

FIGURE 1

```
              INHALATION OF WATER
                  ↓
              Aspiration Pneumonitis
                 and
              alveolar-capillary damage
                  ↓
              Pulmonary Oedema
         ←                          →
        ↓                              ↓
   Ventilatory              Hypovolaemia and
   inadequacy            Circulatory inadequacy
         →                             ↓

              [Hypoxaemia] →  Metabolic Acidosis
         ←
        ↓
    Cerebral
    Swelling    and
        ↓
         →
              Hypercarbia → Respiratory Acidosis
```

The management of patients rescued from near-drowning can be described in terms of the typical intensive therapy patients. There is both an emergency and a definitive phase each of which has both assessment and treatment aspects. The life-threatening lesions require treatment phase and this may need to be instituted simultaneously with or as assessment is going on.

a. Emergency Management

1. Administering oxygen, should it be available when the victim has been brought ashore.

2. Making patent any obstructed airway. This does not mean wasting time emptying the water out of the patient because if it comes when the patient is tipped head down its source is usually the stomach, not the respiratory tree; but refers to extending the neck to lift the tongue from the posterior pharyngeal wall, or using the fingers to clear the mouth of solid vomitus.

3. Breathing inadequacy must be compensated for. If the patient is apnoeic then mouth-to-mouth expired-air ventilation may be all that is possible. If, for instance, a Life-Support team is available on the beach, then perhaps a self-inflating bag can be used. There is one really essential simple requirement to this manoeuvre, however, and that is visual observation to confirm that effective expansion of the chest does occur.

4. If the circulation is depressed this must be restored. Absent heart beat can be compensated for only by external cardiac massage with a firm surface beneath the patient. Again, a Life-Support unit may be able to supply adrenalin and counter-shock, or life-giving plasma to compensate for the volume depletion which has occurred.

One cardinal rule to resuscitation here is that it should be continued until normothermia is established - because even when the evidence of cardiac activity is absent cases have been reported where the heart has started again as the temperature has risen (Smith, et al., 1973).

b. Definitive Management

Victims recovered from water either are apparently recovered or they require attention.

i. patients apparently recovered should still be observed in a hospital because it has happened before that the onset of what is generally called “delayed drowning” can occur and yet the patient die some hours later following drastic deterioration.]

ii. By contrast patients in the other group are obviously ill. They require careful assessment to determine the degree of functional disturbance. The therapy they then require is available on a progressive scale and its particular level will be indicated from the severity of the lesion. The patient must be treated for what is actually found, and not to theoretical expectations of what can happen because it is “salt water drowning” or, because it is “fresh water drowning”.

<u>Definitive Assessment</u>

This has to be made of respiratory, circulatory, neurological and metabolic function.

1. Respiratory. Especially we look for cyanosis, breathing distress, the appearance of fine foaming, white or perhaps pink, at the nostrils or the mouth. Or chest pain, cough, or occasionally wheezing from bronchospasm. Radiological and blood gas assessment will also be available at the base hospital but careful clinical examination and especially determination of breathing distress is probably as useful as any other manoeuvre and does not involve unnecessary delay before instituting treatment.

2. Circulatory. This assessment can be made on examination of pulse and heart beat, and the adequacy of essential perfusion reflected in the pupils and function of the central nervous system. The typical arrhythmias are tachycardia, sometimes atrial fibrillation, premature beats or gallop rhythm. Hypotension may be present, with pallor and sweating, but occasionally hypertension. The best index of peripheral perfusion is, of course, urine formation which requires an indwelling catheter.

3. Neurological. The patient may show irritability or restlessness proceeding even to frank coma, or convulsions. This will be worsened by hypoxaemia and hypercarbia. Sometimes extensor rigidity or extensor spasms or pisthotonos also indicate central nervous system dysfunction. The secondary return of coma indicates a need for therapeutic intervention to treat brain swelling specifically.

4. Metabolic. Probably pH is the most valuable quantity to measure. In collected data on laboratory findings in cases of secondary drowning (Rivers, et al., 1970). The much vaunted sodium and potassium ion changes could not be predicted for individuals according to whether they were sea water or fresh water near-drowning cases. In our own experience, critically ill people generally seem to have a depression of serum potassium level. Electrolytes may need to be measured repeatedly, initially even every hour or two until balance has been restored. The effects of magnesium aspiration in sea water drowning is not as yet elucidated as far as I am aware. Temperature should be monitored, platelet and white cell counts performed but plasma haemoglobin levels would seem to be a fairly fruitless investigation.

Definitive Treatment

The principles of management of the near-drowned with intensive therapy are well established.

1. Respiratory requirements. These are met in the spontaneously breathing patient by administering enough oxygen to abolish hypoxaemia. This may require even a hyperbaric chamber at 2 atmospheres but if hypoxaemia is severe enough to warrant the latter then generally Intermittent Positive Pressure Ventilation with oxygen is indicated. During transportation this may be provided adequately with a self-inflating bag, but definitively it will require endotracheal intubation and ventilator therapy. Severe hypoxaemia is best treated, of course, with end-expiratory pressure, particularly if pulmonary oedema is present.

2. There may have been an immense plasma loss and then circulation will be restored only by volume repletion. The stomach may be full of water and this is best aspirated. Once blood volume has been restored maintenance fluid therapy will be required with electrolyte manipulation according to serial bio-chemical testing.

3. Acidosis. pH needs to be brought to a safe level, ie., between 7.20 and 7.25 by the administration of molar bicarbonate. This also means, however, the administration of molar sodium and in the presence of elevated serum sodium this will further increase osmolality.

4. Sequelae of cerebral hypoxaemia are seen rather more frequently, in our practice and I will describe two cases demonstrating management. The principles of a regimen of active intervention for acute brain swelling have been described previously (Trubuhovich and Spence, 1974; Trubuhovich, 1975).

5. Because of the infective nature of aspirated fluid, antibiotic cover on a prophylactic basis is part of our practice and ampicillin would be our antibiotic of first choice. The pneumonitis may or may not be helped by steroids but noting that evidence on this matter seems to be conflicting we would use such drugs.

Case No 1: A 5-year old boy was pulled out of the water at Great Barrier Island, and found to be stuporose and limp, pallid with cyanosis about the lips, and tachypnoeic at 40-50/minute with some grunting. By the time we reached him by Air

Ambulance from Auckland the tachypnoea was settled, his chest sounded “dry” and he seemed in good condition. Nevertheless, we brought him back to Auckland Hospital for overnight stay because of the slight chance of delayed complications developing. In hospital a breathing rate of 35-40/minutes, settled down in a couple of hours to 20/minutes, but his chest X-ray did show a surprising degree of pulmonic change indicative of interstitial oedema, considering the absence of clinical findings. Oedema had all cleared by next morning when he was sent home.

Case No 2: A 15-year old youth had his head held under water for an indeterminate time by the rigging when his yacht capsized. His companion boatsman applied mouth-to-mouth resuscitation in the water while bringing him all the half mile into the shore. There at 1420 hours, he would not tolerate the Minuteman from the ambulance team, but was given an oxygen mask for cyanosis. At the local hospital he was blue on arrival, not completely unconscious but unable to give any details and he pulled his oxygen mask away. A gastric lavage and a haemoglobin estimation were performed and frusemide (kidney stimulant) was given. When the patient’s breathing looked inadequate he was intubated (against his resistance) then despatched to our department still breathing spontaneously but cyanosed. When breathing further deteriorated during ambulance transportation ventilation with an Ambu bag was attempted. On arrival at the Department of Critical Care at 1540 hours, Ambu bag inflations were noticed to produce an air-escaping noise, and the patient was in black cyanosis with cardiac arrest and fixed dilated pupils. The endotracheal tube was in the oesophagus.

A satisfactory circulation was restored after about 10 minutes’ resuscitation during which the patient received adrenalin 1+1+1 mg, molar bicarbonate 300 mmol (and later 50 ml of Tham. 0.3 M), and plasma. The lungs were extremely non-compliant due to interstitial oedema and intra-alveolar fluid which frothed from the respiratory tree. Artificial ventilation with 100% oxygen, and specific treatment for post-hypoxic cerebral swelling, together with dexamethasone and ampicillin and cloxacillin were continued. By 1600 hours, the central venous blood revealed PO2 51 torr, PCO2 97 torr, pH 7.11, base excess 0; Na ion 161, K ion 3.2, Cl ion 112 mmol/l. Arterial lactate later was 5.7 mmol/l. The admitting hospital now reported haemoglobin at 15.0g/100ml. The occasional ectopic beats were treated with lignocaine, and satisfactory circulatory status was maintained by further administration, of plasma, to a total of 1750 ml by 2000 hours, then a further 1000 ml by midnight. Overnight the potassium requirement was 147 mmol to 0900 next morning.

On the day after admission a disconcerting white cell count of 1.0x103/cmm led to steroids being discontinued, and gentamicin added to the antibiotic regimen for gram negative cover. By the fourth day the patient’s stable pulmonary condition had started to worsen with progressive lung stillness, hypoxaemia and eventually hypercarbia, leading to bradycardia and cardiac arrest responsive only initially to resuscitation. The Coroner’s pathologist demonstrated (i) a very extensive haemorrhagic pneumonitis, which he described as characteristic of severe salt water drowning (see JAMA, 11 Sept 1967; 201: 209-211); and (ii) severe cerebral swelling.

The next two cases are presented to demonstrate that the neurological sequelae to near-drowning, hitherto ill-described, can be managed successfully by specific treatment.

Case No 3: A 16-year old Maori boy described as mentally retarded, was brought from the bottom of the Onehunga swimming pool at 1400 hours, cold and pulseless. After mouth-to-mouth resuscitation and oxygen in the ambulance, he was making only spontaneous breathing gasps by 1415 hours, but in a few minutes was hyperventilating, and had a strong pulse but was still cyanosed. He was in opisthotonus, with intermittent convulsive restlessness, unrelieved at the nearest hospital by diazepam

10 mg intravenous, then morphine 10 mg at 1430 hours. His chest X-ray indicated oedematous lungs so he was given frusemide 40 + 40 mg. The pupils were noted to be large and reacting sluggishly. Though breathing from an MC oxygen mask he seemed cyanosed and arterial blood gas analysis showed a PaO2 of 57 torr pH 7.23 and base deficit 13.5mmol/l. When I saw the patient there at 1520 hours he needed three orderlies and two sisters to hold him down from his “convulsive” restlessness; he was struggling to hyperventilate and was quite inaccessible but extremely irritable. His pupils were markedly dilated and reacting sluggishly. Administration of d-tubo curarine 45 + 15 mg intravenously enabled a little hand-ventilation then endotracheal intubation within a minute. Diazepam 20 mg provided sedation. Following hyperventilation with 100% oxygen the patient then became rapidly pink throughout. He was catheterised, and an intravenous line inserted for plasma administration when his systolic blood pressure dropped to 80 mm Hg. The heart rate was noted to be fluctuating inbursts from 80-120/min. He was then transferred by ambulance to Auckland Hospital on hand-ventilation with 100% oxygen. His problems were considered to be posthypoxic cerebral oedema and pulmonary oedema subsequent to fresh water near drowning.

In our department the patient was treated for acute brain swelling with hyperventilation with 100% oxygen after curarisation and full sedation; strict haemodynamic control, which required 3 units of plasma over the first 2 hours for a slight hypotensive tendency; hypothermia to 34°C, from 38.5°C on admission; and dexamethasone. Pulmonary oedema was treated by end-expiratory pressure of 8 cm wpg added to artificial ventilation. After about 30 minutes PaO_2 was 450 torr. PaCO2 44, pH 7.36, base deficit 0. The only initial problem at management was maintaining an adequate serum potassium level as it tended to be about 3.0 mmol/l. With the appropriate treatment he made a very rapid recovery from his pulmonary and cerebral oedemas and was satisfactory for transfer back to the other hospital on the fifth morning. His mental retardation was not apparently worsened by this episode.

<u>Case 4</u>: An 11 months infant was found at 1830 hours in a home swimming pool pallid and apnoeic but spontaneous breathing commenced only after 7 minutes of mouth-to-mouth resuscitation. When admitted via the Accident and Emergency Department of Princess Mary Hospital after 3 hours he was unconscious, barely responding to painful stimuli, but pupils were reacting to light. Management consisted of oxygen, antibiotics, intravenous fluids (but no dexamethasone). Blood pressure was 150/100 mm Hg, heart rate 140/minute and breathing rate 40/minute. The infant was initially inert with noisy breathing but later became responsive to painful stimuli, was irritable, restless and crying. At 0230 hours generalised fitting occurred for about 90 seconds and half an hour later the patient was given diazepam 2 mg and dexamethasone. He slept more deeply after this and gave a slight response to painful stimulation but following two further fits breathing was shallow although the child was said to rouse to painful stimuli “easily enough”. After further fitting at 1000 hours next morning the patient was referred to our department, and when first seen was comatosed and generally flaccid with focal convulsions; cyanosed and vasoconstricted; and markedly hyponatraemic (Na ion 113 mmol/l at 0900 hours). Systolic blood pressure was 180 mmHg, heart rate 125 per minute, temperature 37.5°C. The infant was sedated, curarised, intubated and received constant hyperventilation with oxygen, anticonvulsants and dexamethasone were given, and 14 ml of molar bicarbonate solution raised the serum sodium level to 120 mmol/l by 1230 hours. The hyponatraemia further slowly improved over the next 2 days. Opiates were required occasionally for some haemodynamic instability.

On the morning after transfer an electroencephalogram was reported as very severely abnormal “even by Department of Critical Care standards”. By the 9th day the patient seemed lighter neurologically though his cardiovascular system was still irregular.

A first trial of decurarisation that day was abandoned because of bizarre and persistent abnormal spontaneous movements but these were of a lesser degree 3 days later so decurarisation was proceeded with and the patient finally satisfactorily extubated on the 14th day after transfer. Consciousness rapidly improved but peripheral tone was markedly depressed, probably because of the large quantities of diazepam and sedating drugs he had required. He was transferred back to the paediatric ward and when seen two weeks later before leaving hospital was described by his mother as being perfectly normal and having acquired new skills and new words.

Summary

An account of near-drowning has been presented to emphasise the dysfunctional sequelae of hypoxaemia, hypovolaemia and acidosis - rather than rapid fluid shifts, electrolyte changes and ventricular fibrillation. Specific treatment can be applied to treat brain swelling subsequent to hypoxaemic cerebral insult.

References

Hospital Circular Letter. Treatment of Drowning. Hospital Circular Letter No *1971/82*.. Department of Health, Wellington; 19 May 1971.

Miles, S. Drowning. Brit M*ed Jnl* 1968; 3: 597-600.

Rivers JF, Orr G, Lee HA. Drowning - Its Clinical Sequelae and Management. Bri*t Med Jnl* 1970, 2: 157-161.

Segarra F, Redding RA. (1974), Modern Concepts about Drowning. CMA Journal 1974, 110: 1057-1062.

Safar Peter (ed). Cardia-Pulmonar*y Resuscitation*. Norway, World Federation of Societies of Anaesthesiologists, 1968.

Smith EH., Pickering D. Near-drowning in Osford Children. Arc*h Dis Child*. 1973; 48: 655.

Trubuhovich RV, Spence M. *Scientific Abstracts, 1st World Congress of Intensive Care*. Glasgow: Bell and Bain, 1974: 85-86.

Trubuhovich RV. Conservative Management of Acute Brain Swelling. *Proc Univ of Otago Med School Centenary*. Dunedin: John McIndoi, 1975: 31.

* * * * * * * *

FOETAL DECOMPRESSION SICKNESS?

Tests on sheep have shown, by inference, that while it is probably safe for a pregnant woman to make a shallow dive it may not be safe for her baby if she makes deeper ones even though they are within the no-decompression limits of the US Navy tables. Experiments at the Texas A and M University’s Sea Grant facility, under the supervision of physiologist William Fife, have involved monitoring of the umbilical arteries by implanted sensors when pregnant sheep were “dived” in a chamber to 30 metres for 25 minutes. Although such a dive profile does not require a human to make decompression stops on ascent (though careful people might include a stop), sheep foetuses were shown to have massive bubble flow of a degree likely to be fatal had not the sheep been recompressed promptly and then brought up at a slower rate. This work is to be reported in detail at a later date in Undersea Biomedical Research, but in the interim a warning is reasonable to women who propose to dive in even the earliest stages of pregnancy lest their babies, like those of the sheep, are more susceptible to bubble production than are they themselves. There are, however, no known instances of such damage occurring.

ADDENDUM: UPDATING FOR 1978

Emphases in management altered from the above regime which would be applied today to patients with post-ischaemic/hypoxic encephalopathy, eg. after a water accident, are:

1. Early loading of the patient with barbiturate to confer "cerebral protection".

   The agent used for this is preferably thiopentone, to 30mg/kg in an hour.

   This may require circulatory support with vasopressor agents. See the Brain Resuscitation Symposium issue in *Critical Care Medicine* to be published in July, 1978, especially the paper by Breivik et al. which details some very interesting cases of resuscitation from near-drowning. See also the issue "Management of Acute Intracranial Disasters" in *International Anesthesiology Clinics*, Volume 16 to be published in early 1979 (Editor: RV Trubuhovich) for the general background.

2. Closer attention to management of serum osmolality in the presence of cerebral oedema.

   (a) A hyper-osmolar state is managed by the administration of near-isotonic saline to reduce serum osmolality gently at the rate of 10(-20) mmol/day.

   (b) A hypo-osmolar state is managed by fluid restriction, and possibly the use of mannitol 20% (0.5-1.0 g/kg) or even frusemide.

Severe disturbances of osmolality and inappropriate management of them can cause fatal deterioration in cerebral oedema.

RN Trubuhovich

* * * * * * * *

FOURTH ANNUAL CONFERENCE on the CLINICAL APPLICATION OF HYPERBARIC OXYGEN

The Fourth Annual Conference on the Clinical Application of Hyperbaric Oxygen is scheduled for Thursday through Saturday, 7-9 June 1979.

In addition to Plenary Sessions dealing with clinical applications of hyperbaric oxygen, nursing and technical applications, and original communications, a Plenary Session devoted to "What's New in Diving Medicine" is added this year.

The first call for Abstracts (200 words or less) on original papers in hyperbaric medicine is made. The deadline for receipt of Abstracts is 15 January 1979. Abstracts should be sent to:

Michael B Strauss, MD
Chairman Program Committee
Fourth Annual Conference on the Clinical Applications of Hyperbaric Oxygen
C/- Baromedical Department
Memorial Hospital Medical Center
2801 Atlantic Avenue
Long Beach, CA 90801

WORLD LIFE SAVING MEDICAL ADVISORY PANEL MEETING
NEWPORT BEACH, CALIFORNIA - 13TH-18TH MAY 1978

Dr Ian Mackie

The World Life Saving Movement was formed in 1971 with the Surf Life Saving Associations of Great Britain, United States, Canada, South Africa, New Zealand and Australia as its principal members. A Medical Advisory Panel was formed prior to the 1972 Congress and this Panel, with representation from all member countries, has met regularly ever since. At the most recent meeting in California, delegates from ten different countries discussed a wide ranging series of topics and listened to presentations of papers from members of the panel in addition to papers from the two special guests, Professor Jerome Modell, Professor of Anaesthesiology at the University of Florida and Dr James Wilson, Professor of Pathology at Oral Roberts University.

The following is a precis of the items discussed at the Meeting:

1. Manual methods of respiratory resuscitation (eg. Sylvester-Brosch and Holger Nielson) were discussed and condemned as having no place in teaching programmes for basic life support. Dr Mark Harries from the United Kingdom presented a paper in which he summarised the scientific evidence for this recommendation. Many papers have been written over the last thirty years on the comparison between manual methods and expired air resuscitation but only the more recent papers have included studies of blood gases. Dr Harries' presentation made it very clear that although in some cases there appears to be some degree of aeration of the lungs, arterial oxygen content drops disastrously in almost all cases when the manual methods are used. By contrast, expired air resuscitation results in highly satisfactory levels of arterial oxygen. There are many lifesaving bodies around the world still teaching and recommending manual methods in 1978.

2. Immersion Hypothermia. The medical literature has been suggesting over the last two years that cardiopulmonary resuscitation should not be performed on the pulseless, apnoeic patient who is profoundly hypothermic; the Medical Panel could find no evidence at all to support this suggestion which emanated from the Royal Navy. All case reports of survival after prolonged immersion in very cold water have included cardiopulmonary resuscitation as part of the initial management. Experts other than those in the Royal Navy believe that CPR should be performed irrespective of the patient's temperature.

   The Medical Panel advised Lifesaving Associations that when first rescued, patients who are conscious or shivering should be warmed actively but in patients who are unconscious the correct management was simply to prevent further heat loss by proper use of a space blanket or whatever type of covering is available. Active rewarming by lifesavers of this type of patient is not advised because of the hazards of the further drop in temperature which occurs immediately after active rewarming has been commenced. It was felt best to leave active rewarming to the hospital scene.

3. Computer searches of the medical literature have been carried out by the Surf Life Saving Associations of Great Britain and Australia on the subject of drowning, resuscitation, hypothermia etc. These Medlars Searches are made available to all members of the Medical Panel and have been extremely helpful in uncovering articles which would not ordinarily be seen by the doctors concerned.

4. The use of mechanical ventilators was discussed at length and members of the Panel were well aware of the complications which have been reported in the literature from the use of certain types of ventilator. While approving the use of mechanical ventilators for lifesavers with special training, the Panel affirmed that in teaching basic life support the emphasis must be on immediate institution of expired air resuscitation. The available machines were reviewed and the Panel felt that mechanical ventilators for use by lifesavers outside hospital should be:

   a) Volume cycled
   b) Manually triggered
   c) Capable of delivering 100% oxygen
   d) Capable of instantaneous flow rate of at least 100 litres per minute.

   The Surf Life Saving Associations which use these ventilators all have restrictions on their use in the form of an Advanced Resuscitation Certificate.

5. The use of Bag-Mask-Valve ventilators was also discussed at length and it was recommended that because these do not produce adequate ventilation for resuscitation in the field they should not be used by lifesavers. It is important for medical practitioners to remember that circumstances inside hospitals and resuscitation performed by lifesavers on a beach are totally different.

6. Resuscitation Report Forms as used by the Australian Surf Life Saving Association were tabled and the usefulness of the statistics gained from these forms applauded. All member countries in future will make strenuous efforts to obtain and collate statistics on their own resuscitations performed in an aquatic setting. The statistics obtained from collation of the Australian Forms were presented and covered 117 immersion victims of whom 40 died and 77 survived. Detailed analysis of the statistics will be reported in a suitable medical journal at a later date, probably when the numbers have increased a little.

7. PEEP in the field was considered especially because of the current availability of an Ambu PEEP valve which could be used outside hospitals, Professor Modell, who is a great advocate of PEEP in the management of immersion victims, was opposed to its use outside hospital and his opposition was echoed by all members of the Panel. Dr Modell felt that if PEEP were to be used outside hospital, the pressure level chosen would be absolutely arbitrary, the effect on venous return would be unknown, the effect on cardiac output would be unknown, and the likelihood of spontaneous pneumothorax or mediastinal emphysema was considerable. He believed that lifesavers were very much better advised to concentrate on prevention, rescue and immediate resuscitation than on PEEP.

8. The question of alcohol and aquatic activity was discussed briefly and a paper on this has now appeared in the *Medical Journal of Australia*, 24 June 1978.

9. The literature on epilepsy and immersion was reviewed and the statistics from the Australian Report Forms added to this. The Panel could find no evidence of an increased risk from swimming for well controlled epileptics.

10. The distended stomach frequently presents a problem to the lifesaver in that it is associated with considerable vomiting/regurgitation and some degree of impairment of diaphragmatic movement. Various lifesaving bodies have given different view points on the safety or otherwise of active drainage of the stomach in these circumstances and some lifesaving Organisations have recommended pressure on the epigastrium or left hypochondrium to assist in emptying the stomach. There was unanimous agreement amongst the Medical Panel that attempts

at drainage are very risky indeed and delay the proper institution of cardiopulmonary resuscitation. There was unanimous agreement that there should be no active efforts made by lifesavers to empty the distended stomach. It was further pointed out that the maintenance of a clear open airway will greatly diminish the risk of gastric distension with air during the performance of Expired Air Resuscitation.

11. Definitions of terms such as ‘delayed drowning’ and ‘secondary drowning’ present a problem to any doctor who follows the literature on immersion episodes, and the World Life Saving Medical Panel is attempting to clarify this very difficult field. Dr Jerry Hughes from California is the American representative on the Panel, and he has been given the task of communicating with some notable contributors to the medical literature asking their support in producing suitable definitions.

12. The precordial thump has been the subject of a great deal of talking and teaching over the years and is discussed at almost every meeting. The current recommendation of the American Heart Association, ie. that the precordial thump should not be taught to or practised by lifesavers. It plays no part in the management of hypoxic cardiac arrest and in such circumstances may well delay the institution of proper CPR.

13. The emergency management of impacted foreign body in the upper airway has been highlighted by the papers of Dr Heimlich and the subsequent spate of recommendations by various Organisations in North America. In the presence of two special guests from California, Dr Stanley Gold and Dr Jeffrey McDonald, the ever-changing recommendations of these Organisations and individual experts were reviewed and discussed. It was clear to the Meeting that there is not a uniform viewpoint on what should be done for emergency management of impacted foreign body, but it would seem, even now, that a sharp thump between the shoulder blades is still the best initial management. The Medical Panel felt that the use of eponyms was undesirable and served only to complicate the issue; the fundamental place of basic airway management was reaffirmed. It was also felt that the present stress on this subject was to the detriment of proper cardiopulmonary resuscitation and an analysis of the American statistics puts this into perspective. In the United States of America each year there are 700,000 myocardial infarction deaths, 8,000 drownings and an unknown number of near-drownings. Against this there is absolute maximum of 2,000 cases of sudden upper airway impaction. It was therefore felt that the various methods of disimpaction should only be taught at an advanced level and not as part of courses of basic life support.

14. There was no disagreement at all on the subject of the best position for the patient being transported. It was uniformly agreed that the unconscious, spontaneously breathing patient should be nursed and transported in the lateral position with maintenance of head tilt and jaw support.

15. Because of the frequency of vomiting during the post-immersion episode the Panel discussed the advisability of performing expired air resuscitation with the patient on his side. This is practised in Vancouver and Nova Scotia, but is not formally recommended by the Royal Life Saving Society of Canada. Member countries and their Medical Panels have been asked to investigate the feasibility of this manoeuvre and to stimulate any appropriate research programmes. There is no known published literature on this subject.

16. Dr Neil Goodwin from South Africa presented a paper on ‘The Diving Reflex in Dolphins’ and showed that in addition to the profound bradycardia there is a

gross drop in blood lactate when dolphins submerge with a dramatic rise in blood lactate when the dolphin resurfaces. An extension of this phenomenon to humans suffering from immersion may answer a query which has troubled water safety experts for years. If the same thing were to happen in humans, then it is reasonable to assume that on retrieval from the water a victim of near-drowning would develop re-perfusion of his limbs with distribution into the systemic circulation of accumulated muscle lactate accumulated because of grossly diminished limb perfusion during the period of immersion. This could worsen the already existing acidosis associated with profound hypoxia and cause either circulatory or respiratory arrest after rescue. The statistics of the Surf Life Saving Association of Australia reveal that for the four years under review, four patients who were breathing following retrieval from the water subsequently required expired air resuscitation and a further two patients who were breathing on retrieval from the water required cardiopulmonary resuscitation. Many individuals and organisations have noticed similar phenomena.

Suction apparatus as used on beaches was discussed and the Panel agreed that the Venturi type suction apparatus is of little or no help in clearing the airway of the patient on the beach. It was pointed out, furthermore, that this system was very wasteful of oxygen. It was further pointed out that the material found in the mouth of a victim of immersion is likely to be vomitus or regurgitant stomach contents and will therefore contain solid material. The use of the lateral position, gravity and the rescuer's fingers continue to be recommended as the methods of choice for removing foreign material from the patient's airway.

18. CPR on the beach was discussed at length and the Australian Surf Life Saving Association figures showing 13 immersion survivors following CPR on the beach were presented. There is a continuing stream of literature on cardiopulmonary resuscitation and this was reviewed. The recommendations from the Panel were;

    (i) Ventilation to compression ratio 1:5 (2 operators)
    (ii) Rate 60 per minute
    (iii) No pause for ventilation
    (iv) Ideally compression should occupy 60 percent of the cycle and relaxation 40 percent. In practice however, a ratio of 50:50 is easier to achieve.
    (v) Short, jerky movements are to be condemned.
    (vi) For one operator CPR in infants, the ventilation/compression ratio should be 1:5 (in adults 2:15).

19. The frequency of fractured neck occurring in the water has been highlighted by many experts and unfortunately to date the medical profession has made no great effort to advise lifesaving bodies on methods of removing a patient with a suspected broken neck from the water. Several members of the Medical Panel took to the beach at Corona del Mar with some highly trained lifesavers and practised methods of removing patients from the water in these circumstances.

    The principles of preventing flexion and lateral movement of the neck were stressed but the practical difficulties became very obvious in surf conditions. Some photographs were taken but this is an area where teaching with film and video tape will be required.

20. Professor Modell's paper on the pathophysiology of near-drowning was more or less a summary of his most recent Journal articles. In addition he presented details of his approach to the modern therapy of near-drowning and gave his reasons for believing that prophylactic steroids and prophylactic antibiotics are, in his opinion, not indicated. Dr Modell was specifically asked to comment on a suggestion from New South Wales that children are less likely to drown in

salt water pools than fresh water pools, but he was not aware of any studies which suggested that this would be true. He knows of no evidence that children were more buoyant in salt water than fresh water.

21. The final session was a stimulating question-answer session involving all the experts. This session has been recorded on audio-tape and will be available in full in written form in the near future.

World Lifesaving will conduct its next Congress in 1982 and a final decision on the venue will be made in mid 1979.

* * * * * * * *

MUSSELS WITH A CURATIVE TOUCH FOR ARTHRITIS?

Marine pharmacologist John Croft and his wife have been working in New Zealand since 1971, their job being to advise on how to "farm" mussels. More than 1,000 tons yearly of the little green-lipped mussels are being reared on an island haven in New Zealand under their guidance, according to a press report. The protein extract from the mussels, which are larger than the normal species and green instead of blue, has no side effects and has been proved to take away pain and increase mobility. This property of the extract was apparently discovered by chance by American researchers looking for a cancer cure. The remedy is said to be in use in the UK and many other countries.

(Lpl. E.P. 15 June 1978)

* * * * * * * *

CIGUATERA POISONING

The Queensland Health Department has disputed claims that an unusual number of ciguatera poisoning cases are occuring this year, though Dr Robert Endean was reported to have related an apparent increase to the eating of mackerel. He noted that while in previous years outbreaks had tended to occur in September and October, this year they had occured in almost every month. A Health Department spokesman, while denying that more cases were occuring, traced the cause to mackerel caught in the Rockhampton, Bundaberg and Gladstone areas and ascribed it to the presence of seaweed as a factor in the contamination.

Symptoms of ciguatera include nausea, diarrhoea, dehydration, a sensation of tingling about the lips, tongue and throat (followed by numbness) and a pathognomic complaint of paradoxical sensory disturbance in which there is a reversal of hot/cold sensations. Extreme exhaustion and muscular weakness are common. Treatment is symptomatic.

* * * * * * * *

DREAMFISH

Norfolk Island has a special drug problem. The drummer fish gives people bizarre dreams and victims can develop the paranoid feeling that others are trying to hurt them.

* * * * * * * *

WORKSHOP ON THE TREATMENT OF DECOMPRESSION SICKNESS

LCDR KM Greene MC USN

This report summarizes a workshop held 17-18 February 1976 in London. The thirty physicians attending from seven nations sought a uniform approach to the treatment of decompression sickness in the North Sea environment.

Aspects considered include recompression profiles, gas mixtures, ancillary drugs, aftercare, qualification of assistants, and communication problems. Included in this report is an outline approved by the EUBS for guidance in the choice of treatment tables.

The continuing expansion of the offshore oil and gas industry involves large numbers of divers in the construction and maintenance of underwater equipment. When these divers suffer decompression sickness (DCS), as they do in spite of the latest decompression techniques, a variety of approaches may be made with regard to treatment. This diversity of treatment exists at all levels, from the supervisor on the scene, through the diving company management, to their medical consultants, whether industrial or naval. Because of the fast pace of development and the multinational complexion of the diving industry, this lack of a consolidated approach is nowhere more evident than in the North Sea.

A more uniform approach might improve the treatment outcome of many cases, particularly when the care of the diver passes through several levels of management or to several medical consultants. Toward this end, the European Undersea Biomedical Society (EUBS) invited a number of diving medicine consultants to participate in an informal workshop, held 17 and 18 February 1976 at the Royal Society of Medicine in London. The goal was to establish consensus, where possible, in the practical aspects of the treatment of decompression sickness offshore. The workshop, chaired by Surgeon Cdr. DH Elliott, RN, was one of a series of “Tables Rondes sur la Biomedicine Sous Mer” organized by the EUBS. Financial support was provided by the UK offshore Operators Association, an oil industry organization. Medical representatives of diving contractors, navies, and civilian medical establishments came from the UK, Norway, France, Italy, Switzerland, Canada and the US. A summary report is to be published in the US by the Undersea Medical Society. In the interest of informality and spontaneity, it was agreed that the participants would not be directly quoted.

The participants were invited to review their individual approaches to the management of DCS as a starting point toward delineating areas of agreement and disagreement. Then the specific components of therapy were discussed in detail.

Recompression profiles The expected differences of emphasis and application related to the backgrounds of the participants were evident. For example, DCS occurring at the surface is treated generally according to the USN or RN standard recompression tables, using oxygen at 60 ft pressure or air at 165 ft. The French, however, also use an intermediate profile with oxygen-rich mixtures at 100 ft. In oxy-helium diving to depths greater than 300 ft, commercial divers often follow short bottom-time schedules, where naval divers would use a prolonged saturation technique. As a result, there are no naval standard procedures to guide the treatment of DCS occurring before surfacing from these deep “bounce” dives. Many firms use a complex set of recompression tables to treat the diver without committing him to full saturation.

Experience has shown that in many cases this kind of manipulation results in recurrence of DCS. The participants agreed that in most cases of this sort, it would be better to recompress to the depth of symptomatic relief and return the diver to the surface on a saturation decompression schedule. In saturation diving, DCS is treated by minimal recompression, but the Royal Navy consultants recommend 30 to 60 ft of added depth without special breathing gases, while US Navy practice favors less depth, with oxygen-rich mixtures.

In the end, the choice of therapeutic compression profile according to the antecedent dive was the area in which concensus was achieved by the workshop. An outline of the agreed approach (see appendix) was endorsed "for guidance" by representatives of the EUBS and the Association of Diving Contractors. One point on which opinion was unanimous was that recompression should absolutely never be undertaken in the water.

While other specific components of treatment were discussed individually, there was markedly less uniformity of opinion. The interchange served to emphasize the rather glaring lack of convincing evidence, of the sort required in other areas of medicine, to support the use of many of the ancillary therapeutic agents. The participants agreed that there was a lack of controlled formal clinical trials. It was suggested that a central case reporting system would also be helpful in the evaluation of various modes of treatment.

<u>Drugs</u> The use of various ancillary drugs was advocated for nearly all cases of DCS by the French representatives. Others rarely used any, particularly in the offshore setting. Most of the practitioners present used one or more drugs such as dextran and glucocorticoids only in severe cases. Dextran was recommended by most, although it, like all the other agents discussed, is not backed up by controlled clinical trials involving DCS. Its properties and use in other diseases were reviewed. Although dextran-40 (40,000 molecular weight) is the most widely used, there was discussion of the relative merits of dextran-70. Some potential advantages were claimed for dextran-70, for example, longer persistence in the circulation and greater anti-platelet effect. One potential disadvantage of dextrans is the tendency to inhibit blood coagulation. This was said to occur, however, only when a dose of two or more litres was exceeded in 24 hours. One participant felt that this possibility contra-indicated its use in DCS of the inner ear. Specific indications and dosages could not be agreed upon.

Glucocorticoids were mentioned by some discussants for use in DCS of the central nervous system, particularly in the absence of satisfactory initial response to recompression. The rationale involves reduction of oedema in the affected areas of the spinal cord or brain, or the preservation of ischemic cells. This use of glucocorticoids is based primarily on inference from other clinical applications. The dosage suggested by its advocates was 10 to 12 mg of dexamethasone intravenously, followed by maintenance over as long as three days, using about eight mg every six hours. This is similar to the regimen used for cerebral oedema in brain tumor patients. On the other hand, one member of the group cited studies in animal surgical shock models, which showed that the beneficial effect of protecting hypoxic cells required doses of steroid many times greater. There was no concensus on the indications or dosage for steroids in DCS.

Heparin has been used occasionally in severe DCS, based on a few animal experiments-in the absence of clear evidence of efficacy in human DCS, the potential risk of hemorrhagic complications at the site of the lesion (eg, central nervous system, inner ear) discourages its use.

Asprin was endorsed by the French representatives for all cases of DCS. Others pointed out that there was evidence only for a prophylactic effect in animals, and no demonstrated value in treatment beyond mild analgesia.

Diazepam was said to be used frequently by the French, but apparently only as a non-specific tranquilizer. One participant also noted its specific effect of suppressing the symptoms of vestibular damage. It could thus be used after treatment failure in inner ear DCS, but should not be allowed to obscure the response to recompression. A few other less important drugs were also discussed and not endorsed by the group.

The aftercare of DCS patients was also considered. In cases of inner ear damage, follow-up with audiometry and electronystagmography was emphasized, since even with complete loss of labyrinthine function, symptoms may resolve within a few days. In the case of residual spinal cord damage, repetitive hyperbaric oxygen therapy was recommended by some. It was agreed that daily treatment could be continued as long as it was accompanied by steady improvement.

The participating doctors were asked to describe the kind of assistant they would like to have in an offshore treatment chamber in the absence of a doctor. Despite lively discussion there was no concensus on either the type of training required or even the scope of medical procedures which should be required of the assistant. Suggestions ranged from divers with advanced first aid training, to fully- qualified Physician’s Assistants. All agreed that improved telecommunications were needed between an offshore facility and the doctor ashore, and that a personal rapport between doctor and assistant was more important than the level of qualification of the assistant.

* * * * * * * *

continued from page 63 ...

5.3 Any deterioration of the patient during the compression following a therapeutic compression should be treated by further compression to the depth of significant relief.

5.4 This outline is for guidance only since it cannot predict every situation and some differences of opinion may still exist on details of treatment between medical practitioners experienced in this field.

* * * * * * * *

APPENDIX

THE CHOICE OF A THERAPEUTIC COMPRESSION TABLE IN RELATION TO THE CAUSATIVE DIVE (AS RECOMMENDED BY REPRESENTATIVES OF THE EUROPEAN UNDERSEA BIOMEDICAL SOCIETY AND THE ASSOCIATION OF DIVING CONTRACTORS, LONDON, FEBRUARY 1976)

1. Air diving

Decompression illness arising at the surface following air or oxy-nitrogen dives (of a duration less than saturation) should be treated in accordance with one of the following procedures:

1.1 Immediate Treatment (If Not Life-Threatening)

i. Compress chamber with air, breathing oxygen from the surface to 60 ft (18m)

ii. At 10 mins review:

- if limb-bends cured - USN 5 or RN 61
- if serious symptoms cured - USN 6 or RN 62
- if improving - remain at 60 ft (18m) and at 45 mins review:
  - if cured - USN 6 or RN 62
  - if not cured - USN 6 with extra oxygen sessions
- if symptoms worsening - off oxygen and compress to 165 ft (50m) AIR
  - if on arrival at 165 ft (50m) limb-bend is cured, use USN 2A (RN 52) but for all serious manifestations use USN 4 (oxygen at shallow stops compulsory for patient and attendants) or RN 54.
  - French-trained divers would tend to use 30m oxygen-rich rather than 50m air tables.

1.2 Immediate Treatment if Life-Threatening or if Cerebral Air Embolism is Suspected

Proceed direct to 165 ft (50m) AIR. Do not spend time on oxygen at 60 ft (18m).

For air embolism the US Navy now use table 6A, but Royal Navy experience favours a version of USN 4 (RN 54) using a continuous rate of ascent (18 to 10m at lm/hr, and 10m to surface at 0.5m/hr) in place of stoppages from completion of 6 hrs at 18m.

1.3 Treatment After Some Five or More Hours’ Delay Between Onset and Compression

Use USN 6 (RN 62) with extra oxygen sessions as needed. Frenchtrained divers also would use 18m oxygen tables but with a 30m oxygen-rich option if there is no relief after 15 mins.

2. Saturation Diving

2.1 Treatment During Saturation Decompression

For the onset of decompression sickness during a slow saturation decompression breathing oxy-helium or other mixtures, compress at 5 ft/min (or 2m/min) to depth of significant relief, but by not more than 2 bar (60 ft; 20m) for pain-only limb bends and by not more than 3 bar (100 ft; 30m) for serious decompression sickness, inner-ear manifestations in particular.

It is worth noting that the onset of inner-ear decompression sickness may be associated with a recent switch from helium to air during the decompression. If compression is required in these circumstances, the patient should be returned to an oxy-helium atmosphere. For this reason alone, when the change to air is made, it is advisable to keep one of the chamber compartments not being used by the divers at the time filled with oxy-helium. Thus it is immediately available for any necessary treatment during the period following the change to air.

Remain at that depth for a minimum of 2 hours and possibly 6 hours. Oxygen-rich mixtures (1.5 to 2.5 bar O_2) may be breathed for up to six 20-min periods with 5-min intervals on chamber atmosphere.

Resume saturation decompression from treatment depth, but with initial upward excursion.

2.2 Excursion Diving From Saturation

Following an excursion, immediate compression is necessary to the depth of relief. This depth may be less than the depth of excursion, but for serious symptoms it should be not less than 3 bar.

Remain at the treatment depth for a minimum of 2 hours, for as long as improvement occurs and possibly for as long as 24 hours.

Oxygen-enriched mixtures may be used (as in 2.1). Initiate saturation decompression from treatment depth, but with no initial upward excursion.

3. Oxy-Helium “Bounce” Diving

Deep oxy-helium dives from the surface, with a bottom time of relatively short duration, which lead to decompression sickness during the course of, or soon after, a decompression more rapid than used for saturation diving.

3.1 Onset of Decompression Sickness at the Surface

Breathe oxygen by mask from the surface and compress chamber with air to 60 ft (18m). If cured or improving after 10 minutes, continue oxygen treatment as detailed in paragraph 1.1.

If condition not improving at 10 minutes, discontinue oxygen and compress chamber to depth of relief, using pure helium. (This incoming gas must be well-mixed, perhaps by venturi, with the chamber atmosphere of air and the divers should breathe an oxy-helium mixture by mask during the compression until mixing is complete.)

If the condition is serious at the surface, compress to 60 ft (18m) with air but do not stop at 18m. Continue on helium to depth of significant relief.

Ideally, the chamber should have a partial oxygen pressure of about 0.4 bar at all times, the diver breathing a higher-oxygen mixture by mask (as in 2.1), as needed. (The upper limit of oxygen in the chamber atmosphere should be 0.6 bar). Since the chamber contained 2.8 bar air and was further compressed using 100% helium, the chamber atmosphere will have a partial pressure of oxygen of about 0.6 bar, whatever the depth of relief.

Other methods of achieving an acceptable atmosphere are possible, but need to be carefully planned in advance.

Remain at least 2 hours (as in 2.2), after which decompression should be initiated on a saturation table, but with no initial upward excursion. For guidance the following rates may be used:

deeper than 100m	1.5m/hr
100 to10m	1.Om/hr
10m to surface	O.5m/hr

3.2 Onset of Decompression Sickness During the Original Decompression

- Immediate compression to the depth of relief and, if relief is not achieved, to at least the full depth of the dive.

- Remain at least 2 hours, optional oxygen-enriched breathing mixtures (as in 2.1 and 2.2)

- Begin saturation decompression from treatment depth, but with no initial upward excursion.

4. Uncontrolled Ascent (Blow-Up) to the Surface

The unscheduled surfacing of a diver is hazardous at all times but especially so if he has not completed all the necessary stoppages.

0NE MUST ALWAYS BE PREPARED TO COMPRESS THE DIVER, IMMEDIATELY UPON SURFACING, IN A CHAMBER TO THE FULL DEPTH OF HIS DIVE, AND, IF NECESSARY, TO DECOMPRESS ON A SATURATION SCHEDULE.

5. Notes for all Classes

5.1 Attention must be paid at all times to preventing pulmonary oxygen toxicity. A UPTD (unit pulmonary toxicity dose) of 615 (equivalent to a reversible 2% decrement of vital capacity) should not be exceeded, thus allowing latitude for any further treatment.

5.2 The rate of decompression should be determined by the condition of the patient, symptoms usually being a more sensitive guide than outward signs.

continued on page 60.

PATHOLOGICAL INVESTIGATION OF THE FATAL DIVING ACCIDENT

Dr Ian M Calder.
Institute of Pathology, The London Hospital Medical College, London.

Fatal accidents are fortunately rare in the Diving Industry and occur at widely dispensed geographical points. This may result in rather inadequate investigation and interpretation of findings due to local lack of knowledge of diving physiology and pathology.

The ultimate aim of the investigation of a fatal accident is to accurately determine how, when, where and by what means the person met his death. This naturally implicates the pathologist as the primary investigator, who undoubtedly will need some guidance in specialist fields, but necessitates team work to interpret the findings. In the context of diving accidents this includes Clinicians, Diving Supervisor, Diving Inspector and witnesses as well as any other experts considered relevant. With this an accurate Clinico-Pathological diagnosis may be made.

It is imperative that where possible, the site of death be accurately determined. This may be on the bottom, during ascent and/or during decompression or on the surface, all of which may have resulted from malfunction of apparatus or personnel.

A major problem is the correct interpretation of findings of gas bubbles which may be artifact or a relevant definitive finding. The gas bubble/blood interface examined histologically may produce useful data for example in determining whether a vital circulation was present when bubbles formed - a vital clue.

Whole body X-ray is mandatory, not only for the determination of bone lesions, but for the general appraisal of gas in body spaces before invasive techniques destroy the evidence.

Having obtained the information it is vital that it be recorded centrally and it can be retrieved for use in comparison with other obscure cases, where less information is available, and difficulty is possible in interpretation. In the United Kingdom this is undertaken by the Medical Research Council Decompression Sickness Panel.

As a result a pattern of accidents may be built up, which in the long term can be used in the realm of Preventive Medicine, so that similar accidents do not recur. The accumulation of data and material is vital as part of a prospective study on the effects of prolonged exposure to a hyperbaric environment.

---

* * * * * * * *

DIVING IN THE NORTH SEA DURING 1977 - SITUATION REPORT

Commander SA Warner, MBE, DSC; Chief Inspector of Diving, United Kingdom

Mr Chairman, Ladies and Gentlemen, I certainly feel at home talking to the United States Association of Diving Contractors and associated members. I feel that my annual paper is becoming a habit. A habit which I personally am delighted with, both from the social and the professional point of view. Good communications, in my opinion are absolutely essential for the safe operation of the offshore diving industry throughout the world. Thank you for inviting me once again.

The first subject in my situation report from the North Sea for 1977 must cover accidents. Throughout the whole of the North European area there were five fatal accidents. Three of these were in the British sector and two in the Dutch sector. I am pleased to report that the improvement trend is continuing and, if one measures the accidents against "exposure to pressure time" the improvement is considerable. However, we must not become complacent because these figures are still not good enough.

What have we learnt from the accident investigations of 1977? Unfortunately with one fatality we have to admit that we do not know the answer. One can put forward many hypothesis and theories as to why a "bell man", to all intents and purposes, fainted and fell with his face underwater. We have eliminated every checkable possibility and we are still without hard proof to support a factual conclusion. This is the worst type of accident that we have to investigate. How can one try and prevent it happening again if one cannot find the real cause?

In another case, almost certainly, the over centre clamp of the diver's helmet came open and the helmet came off.

The other case in the British sector is still under investigation but we do know that the diver was wearing SCUBA with a free mouthpiece and diving in turbulent water around a stinger.

There have been a number of near misses and non-fatal accidents. Once again I have to report on a diver receiving an electrical shock from a defective electrically heated suit, plus one this year. In general, the area which has created the most worry during 1977 has been air diving. It would appear that many of the air diving supervisors can convince themselves that providing a dive is carried out to an acceptable schedule it is bound to be safe. Unfortunately this is not true. However, because of their apparent implicit faith in the schedules some supervisors have disregarded, or refused to acknowledge, the presence of serious symptoms and have always found excuses such as cramp to disregard these symptoms. I can find very little excuse for this approach. One only has to follow the "tick-off list" in the United States Navy Diving Manuals to avoid the very serious consequences that can arise if serious symptoms are not treated correctly. On three occasions in the UK sector last year what should have been a normal therapeutic treatment ended up as an air saturation therapy.

As I told you last year, I have a continuous process of analysing the facts and figures gathered from fatal accidents. The up-to-date break-down of this information (viz 39 fatal) is:

Human error was a factor in	19 cases
Poor physical condition in	3 cases
Inadequate training in	6 cases
Equipment failure in	10 cases
Lack of equipment or wrong choice of equipment in	4 cases

Inadequate medical supervision	2 cases
Poor diving supervision in	7 cases
Poor equipment maintenance in	4 cases; and
we do not know the answer in	3 cases

In 1977 it was necessary to prosecute a diving company and a supervisor in the same company for failing to comply with the regulations.

Last year I told you that the United Kingdom Government was combining the four different Statutory Instruments on Diving Safety into one set of unified regulations. I had hoped that by now they would have been issued to the industry for consultation but I regret to say that so far this has not yet been done. The policy is still the same and, although there is little or no change in the offshore diving regulations there will still be a considerable period allocated for consultations before the new regulations become law.

In 1977 there were two major blow-outs in the North Sea, one in the Norwegian sector and one in the Danish sector. Fortunately, on both occasions there were no divers under pressure. As you can imagine these accidents have generated considerable activity not the least of which has evolved around the safe evacuation of personnel. The safe evacuation of divers under pressure from a local emergency presents an extremely difficult potential problem. I say potential, because, to my knowledge, in the whole history of the offshore industry only once has it been necessary to evacuate divers under pressure. In fact in this particular case they could have remained on board with safety. However, I think that it is right that the industry should anticipate this problem and produce contingency plans to cope with it if and when it might happen. We must also consider the morale of the divers. All United Kingdom diving legislation requires action to be taken in the planning for total evacuation. However, ONE MUST NOT FALL INTO THE TRAP OF MAKING THE SITUATION MORE DANGEROUS BY PREMATURE IMPLEMENTATION OF BADLY THOUGHT-OUT EVACUATION PROCEDURES.

During the period 1955 to 1974 there were 70 major mobile rig mishaps and 20 minor mobile rig mishaps worldwide. The vast majority of these mishaps occurred during transit.

Evacuation can be necessitated by fire, collision, extreme weather, blowout, etc. It is essential that the possibility of such emergency be considered first and foremost with a view to minimising the risk, and second to develop a planning response to an emergency should it arise.

Whichever way one assesses the risk to divers under pressure it is minimal and if and when the need to evacuate divers arises there is no one technique that could possibly cater for all sets of circumstances that could arise. However, an emergency situation could always occur and emergency procedures and possibly special hardware may save lives. The undoubted fact that all disaster situations cannot be catered for should not delay action to cater for should not delay action to cater for an appreciable fraction of the eventualities.

Good communications between drilling operatives and the diving supervisors to ensure that diving is not undertaken during operations involving high risk is essential. Such things as: ballasting of semi-submersibles, rig work overs, drilling operations when entering known or suspected hydrocarbon zones, etc. should form the basis of communications between the drilling operatives and the diving supervisors.

The North Sea is now covered by a “helicopter lift” chamber evacuation system and diving companies have been encouraged to make their chambers compatible by the fitting of the necessary adaptors or spool pieces. Once again this system does not cater for all sets of circumstances, but it could be invaluable under some conditions.

As I have said before we may be dealing with a completely impossible situation for providing total coverage but I am convinced that we can cut a minimal risk to an even smaller minimal. We can erode the possible dangers by planning to cater for the problem which may arise under various sets of circumstances.

Evacuation under pressure must be classed as the ultimate emergency, the emphasis being placed on prevention, continuing awareness and immediate response. However in the final analysis we must accept that in every walk of life there has to be an acceptable level of risk.

I personally think that many of our problems could be overcome in the very long term by diving companies and manufacturers getting together and agreeing a common chamber and bell mating technique and common sizes.

RESEARCH

The UK research programme is continuing and the numbers of projects are increasing.

Research into diver unconsciousness is progressing as is that into the use of anaesthetics under pressure.

For many years we have been extremely worried about electrical safety underwater. There are so many widely divergent theories on what is safe. It is our intention to publish a document covering all the points that are known and understood. We then intend to identify the areas where knowledge is either thin or completely lacking. We will then investigate those particular areas.

The project investigating the safe comfortable temperature tolerances under helium pressure is well underway.

There is already an extensive literature concerned with thermal balance in the human being in hyperbaric oxyhelium environments; both theoretical and experimental studies are numerous. Many groups of workers have reported on widely varied conditions. Our main objective is to attempt to draw together this literature and formulate from it the most appropriate thermal balance equations for any specified set of conditions. Some experimental measurements will be made and used to test the validity of the equations. Once reliable thermal balance equations have been derived it should be possible to draw up guidelines for safe thermal conditions.

The doctor carrying out this particular project has said “Some of my reading on food intake and weight loss in divers has led me to suspect that the usual form of thermal balance equations (as applied to 1 ATA air) may be inadequate in hyperbaric oxyhelium. At the moment this is no more than an idea but because of this we are keeping an open mind about the format of the equations.”

I hope that in the very near future we shall be supporting further research into “air saturation” diving because there is very little doubt that this technique could become very attractive in the installation, inspection and maintenance phase of the offshore industry.

As we all know saturation diving is a relatively new kind of potential occupational hazard where individuals are exposed for weeks on end to an environment abnormal in every respect. Except for short term effects such as otitis caused by infection the only known long term indication of physiological or pathological damage is the broadly investigated phenomenon of bone necrosis, but less than a decade is a relatively short period to assess other possible long term damage.

If there are any potential long term ill effects an early indication of these would be most desirable to determine which aspects of the occupation were responsible for such effects. If in fact there were any, this would be the first step towards prevention.

It is our intention to initiate research to cover this. Information received from these various research projects will be made public.

In 1977 15 diving safety memorandas were issued and covered such things as:

- Diving medical emergency information
- Diver qualification requirements
- Defective Synflex fittings
- Requirement for diver heating
- Manning levels and frequency of diver practice
- Danger of surface orientated diving
- Possible dangers of high oxygen partial pressure in NOAA air saturation tables
- The use of air tuggers
- Error in the marking of some high pressure hoses
- Cathodic protection
- Protective headgear
- Transfer under pressure by helicopter
- Neck clamp of Kirby Morgan 16 helmets
- US divers regulators
- Accident reporting

Mr Chairman, gentlemen, I have intentionally kept my paper short this year because I feel that the question period is so important and I would like to make myself available for all your questions.

* * * * * * * *

SNIPPETS

Some people are abnormally sensitive to decompression sickness. One New Zealand diver is so liable that he must limit himself to 20 foot depth maximum.

Chest pain after a dive may indicate mediastinal emphysema or myocardial ischaemia.

Many divers are too buoyant to maintain a 10 foot or 20 foot decompression stop depth. Sport divers should avoid dives requiring decompression stops.

Cold gives little warning of the onset of Hypothermia. Abnormal behaviour (forgetfulness) may occur. 70% of the human body is within 2.5 cms of the surface. Activity increases heat loss. Danger period continues after the victim has been removed from the water. Heat loss occurs even in “warm” water. Severe but reversible hypothermia may produce a deathlike appearance and therapy be wrongly thought useless.

In-water oxygen therapy can be limited to 10 metres by so limiting the length of the gas supply hose.

* * * * * * * *

DIVING SAFETY MEMORANDA NO. 18 1978

The Offshore Installations (Inspectors and Casualties) Regulations 1973

Commander SA Warner, Chief Inspector of Diving
Department of Energy - Petroleum Engineering Division; Millbank London SWiP40J

Your attention is called to Regulation 11 of Statutory Instrument 1973 No 1842 The Offshore Installations (Inspectors and Casualties) Regulations 1973. Regulation 11 states that no person shall disturb the place where a casualty has occurred or tamper with anything thereat before:-

(a) The expiration of three clear days after the owner of the Installation has, pursuant to Regulation 10 (a), given to the Secretary of State information relating to the casualty;

or

(b) An inspector has concluded an investigation of the casualty; whichever first occurs.

Providing that nothing in this Regulation shall prohibit the doing of anything by or with a consent of an inspector.

This Regulation must be applied with common sense when dealing with a diving accident. First and foremost every action necessary to ensure the safety of other people involved in the operation must be taken.

If in doubt, contact a diving inspector.

* * * * * * * *

SEA SECRETS - (Jan-Feb 1979)

QUESTION: I understand that people who are cut in the water can bleed to death. How do fishes that are cut stop bleeding and survive? DH, San Diego, California.

ANSWER: A person who is severely cut in the water can indeed bleed to death, not because the water prevents the blood from clotting, but simply due to the severity of the wound. Small cuts will clot, even underwater. Fishes have clotting mechanisms similar to those of humans. Additionally, in fishes, man, and other vertebrates, the blood vessels of a wounded area can constrict, reducing further blood loss through the wound.

1.51(17) 3382

* * * * * * * *

When the Pepsodent “Ring of Confidence” isn’t enough!

In a recent Science Survey talk, on what is quaintly called “steam radio”, the speaker digressed from horrible tales of the weird and somewhat unethical things psychologists and psychiatrists (and others) do to increase the beastlyness of man on man in war in order to note the use of animals as aids in the detection of the enemy. The training of dolphins is well known now but the training of dogs to smell for exhaled breath of divers as they surface in harbours may be less reported. This would seem to mean that any well trained saboteur should insist on an oxygen rebreathing set if he hopes to escape detection.

DIVING SAFETY MEMORANDA NO. 17 1978

Responsibilities of a Diving Supervisor

Commander SA Warner, Chief Inspector of Diving
Department of Energy - Petroleum Engineering Division; Millbank London SWiP40J

There seems to be some misunderstanding regarding responsibilities of diving supervisors in the Offshore Industry. First and foremost, the Installation Manager or Captain of the vessel is in overall command. He has the authority to stop all diving activity if he considers it necessary for some reason or other; however, he does not have the authority to override the supervisor and order him to carry out diving operations if the supervisor considers it unsafe.

Regulations require that the employer of divers/diving contractor shall appoint in writing a competent person, who has adequate knowledge of the diving techniques to be used in the diving operations for which he is so appointed to carry out in relation to those operations the duties imposed by regulations upon the diving supervisor and shall secure that all divers engaged in diving operations and diving operations carried on, or to be carried on, by them are under the immediate and effective control of that person. In other words the diving supervisor is always to be in control of all diving operations with the exception that the Installation Manager/Captain has the overriding authority described in the first paragraph.

There also seems to be some doubt as to the status of a medical officer who may be called in to deal with a medical problem.

Always and at all times the diving supervisor must be in control of the diving operations. He should however, naturally, take advice from a suitably experienced medical practitioner when applicable.

There are very few doctors specialised and experienced in underwater/ pressure medicine. For instance a doctor who has been a member of a diving team has an obvious advantage over a doctor whose diving experience is confined to the routine of medical examination of divers and this should be considered when making decisions.

There also seems to be a vast number of so-called “Diving Consultants” in the Industry for whom there are no standards of qualification, neither are their duties included in legislation.

Whilst every effort to improve diving safety is encouraged, interference into the responsibilities of a properly appointed diving supervisor cannot be accepted.

* * * * * * * *

SUBSCRIPTIONS

Members pay $20.00 yearly and Associate members $15.00. Associate membership is available for those neither medically qualified nor engaged in hyperbaric or underwater related research. Anyone with an interest in joining should write to Dr John Knight, Secretary of SPUMS, 80 Wellington Parade, East Melbourne, Victoria 3002. Membership entitles attendance at meetings and the annual Conference, and receipt of the Journal/Newsletter.

SPUMS SCIENTIFIC CONFERENCE - SUVA - JUNE 1978

The following precis of the paper has been prepared by Dr John Knight.

THERMAL PROBLEMS OF DIVING

Glen Egstrom

In 1965 Cousteau stated that cold was the biggest problem for divers. It still is. Water temperatures in California vary between 5°C or a bit more in winter to the low 20s in summer. These temperatures require good thermal protection if the diver is not to get thoroughly chilled. Even so cold terminates many dives and divers shiver when they come out of the water.

Humans can adapt to cold. This was demonstrated by studies of the Korean diving women, or Ama, carried out in 1966. They dive without protection or insulation. They are fitter than their non-diving compatriots. They dive two three hour shifts a day with a thirty minute break between sitting by a fire. They free dive in shallower water up, to 10 metres, once every two minutes. For deeper dives, up to 30 metres, they use a weight to take them down. They average a bottom time of a minute. At 30 metres they dive once every four minutes. They have real cold adaptation with a raised BMR and a lower shivering threshold. Measurements showed that they voluntarily stop diving when they reach a rectal temperature of 34°C.

The best insulation is a dry suit. There was an American in the 1890s who had made a reputation in winter rescues at sea. A rubber manufacturer made him a waterproof suit to help him in his rescues. It was so efficient that he was able to have it developed into a drysuit which allowed him to float down rivers all over the world. This principle was taken up during the Second World War when an immersion suit over flying clothes effectively prolonged survival in Arctic seas many times. Until the advent of the immersion suit the pilots of crashed planes were dead when picked up, often within five or ten minutes of ditching.

The wet suit works by trapping a layer of water against the body. This layer warms up to skin temperature and is insulated from the rest of the ocean by the bubbles in the neoprene. Wet suits are compressed with depth and so become much less efficient insulators. For best results the hood should be integral with the jacket, which should have a spine pad, to fill the vertebral gutter and reduce water movement in the suit. The most efficient wetsuit is skin two sides (smooth both sides) as this is the minimum surface area. Textured wetsuits have an extra surface area of about 30%. This leads to extra evaporative cooling out of the water. Nylon 2 has even more extra surface area to loose heat from.

Electrically heated suits have been tried and found wanting as there are troubles with wires breaking at movement points.

The best method of adding heat to the diver that is in use at the moment is the hot water suit. Hot water is pumped down to the diver through an umbilical. The umbilical restricts his mobility by one third.

Dry suits are excellent insulation, but have buoyancy problems. Thermal regulation is controlled by the hypothalamus and is automatic.

Man functions in a range of ±3°C. He is incapacitated soon after exceeding these limits. The comfort range is only 1.5°C each way and the body undergoes considerable changes to maintain itself in this range. Man contains about 6,000 to 7,000 calories. He develops problems if he loses or gains 300,000 calories.

When core temperature drops 1°C metabolic heat production is increased, and shivering starts if it has not already started. When the body is cold, and is removed from the cold environment, the core temperature continues to drop, the afterdrop, which can be as much 2°C. This can cause problems with cardiac action.

Vasoconstriction and continuing cold eventually leads the cold dilatation. Here the blood vessels become temporarily unconstricted, allowing normal blood flow. This warms the extremity, and heat loss rises. Then the blood vessels contract again. The process is repeated at intervals.

If you get hypothermic enough to stop shivering and feel good, you are likely to vasodilate due to lack of central control as you have little heat production you lose heat very rapidly.

At 34° C there is a definite drop in performance. Below that performance is very poor.

A well protected diver in a quarter inch wet suit will demonstrate a decrease in efficiency after an hour at a water temperature of 65°F; he has a 30% loss at 40°F. Simple well learnt tasks are less affected than complicated less well learnt ones. Fine digital manipulation suffers an 80% loss after one hour in cold water. Manual assembly offers a 60% loss.

High heat loss areas are the head, which has virtually neither insulation nor vasoconstrictive capacity, base of neck, sides of chest and axillae, and the groins. This has been demonstrated by thermography.

Heat adaptation; those from hot climates feel colder in cold water than those accustomed to the cold water. When you move to the tropics you dive without a wet suit at first, but soon find that a wet suit is necessary to preserve thermal balance.

Hayward et al. have shown slower cooling in water if groups huddle close or if individuals adopt Heat Escape Lessening Posture. This is a significant improvement over drown proofing as you keep your head out of the water and so loose less heat.

Divers are not only at risk from cold, for two men died in the North Sea oil fields from hyperpyrexia. A combination of circumstances resulted in extra pressure being added to a warmed chamber and the heat load of compression was fatal.

In saturation diving divers lose weight. Some of it is water loss, but some of it is body tissue. Up to 25 lb have been lost by divers in saturation in the North Sea. By losing body weight the diver loses heat tolerance. The lean lose weight faster than the fat.

Rewarming methods range from hot baths, to inhalational warming (which has problems to overcome) to passive warming.

Hayward et al. have designed a jacket, which looks like a thick windproof slicker, which has quarter inch neoprene inside it, which is for use on boats or watersides. If you fall in the jacket is buoyant and floats you had up, and there is a flap inside which allows it to convert to the top half of a wet suit so providing good thermal protection. The U-Vic Thermofloat is available in Australia from Protector (safety equipment firm).

DIVING SAFETY

Glen Egstrom 19 June 1978

Precis by John Knight

Diving is no more dangerous than some other sports. Knowledge of the risks is helpful.

Problems are that the medium is different, masks give tunnel vision, breathing is restricted, the wetsuit gives extra buoyancy, so lead is needed to counter weight, tank harness is restrictive, as is the buoyancy compensator and the buckles are invisible. Added to all this is the extras that divers take, cameras etc, and water conditions, such as surf.

Successful adaptation is the key to safety. The safe diver asks “is there anything I ought to know before I dive” in strange places.

Although more people are trained each year deaths are proportionately steady. Deaths occur mostly in the newly trained and those diving in strange conditions.

Dr Edstrom then discussed various barriers to performance. Among them were badly fitting equipment and he instanced an eight year old with adult equipment. The extra loss of binocular vision that comes with nose covers in masks was noted as was the physiological energy costs of swimming rates and fin sizes. Fin stiffness and size requirements vary with the individual and the workload. Metrological barriers included the right way to drop a weight belt, and the almost undroppability of some home made belts. Regulator performance is usually excellent at the surface but less good at depth and low pressures. The resistances to breathing vary considerably with depth and respiratory rate. At 6 breaths a minute (BPM) most have satisfactory resistances, at 15 BPM most are not so good when deep, and at 30 BPM and deeper than 40 metres most have more than 40 cm of water resistance to inspiration. Buoyancy compensators tend to have the bag out of the water and some float the unconscious diver face down.

DROWNING

Darryl Wallner 19 June 1978

About 8,000 people die in the USA each year from drowning. This is about 10% of accidental deaths and 47% of deaths in children under four. For the ACT the death rate from drowning is 4.7 per 100,000 of which 2.6 per 100,000 is in freshwater.

The basic problem is water in the lungs causing intra-pulmonary shunts which last for 24-40 hours. There is an increased A-a Oxygen difference which can be 300 to 600 mm Hg. The decrease in PaO_2 lasts longer than the shunt.

In salt water, which is hypertonic, there is alveolar damage and inhalation of particulate matter. In fresh water, which is hypotonic, there is loss of surfactant leading to alveolar collapse and damage. In both cases there is pulmonary oedema and shunting.

An added hazard is the association of hypothermia. In 15°C water an adult will last two hours before becoming unconscious, but an eight year old boy will last only about thirty minutes. The hypothermic heart doesn’t function well, there is considerable acidosis in the tissues. There are problems with rewarming. Ventricular fibrillation can be precipitated by injudicious treatments such as External Cardiac Massage, sudden postural changes, intubation, temperature probes being inserted, hyper-ventilation, cardiac stimulants. In acute hypothermia the treatment is rapid rewarming.

Treatment of drowning is first expired air resuscitation and then to hospital. The victims may need ventilatory support, oxygen, PEEP. They can develop pulmonary oedema 12 or more hours after the incident. X-rays are useful for following the changes of the pulmonary oedema. They can develop pulmonary necrotising pneumonitis days later.

In one series there were the following complications.

Pneumothorax	75
Pneumomediastinum	65
Gastrointestinal bleeding	33

(Disseminated intravascular coagulopathy and stress ulcers)

Neurological sequelae were found in 12%. All had been comatose, had intensive cardiopulmonary resuscitation, a pH less than 7 and been mechanically ventilated.

The doctor should be worried about those with changes of consciousness (should stay in hospital at least 24 hours) and those with X-ray changes in their lungs.

In a series of 91 cases from Florida those who had normal chest X-rays were all alright, those who were conscious and alert on arrival at hospital all did well. Those who were comatose died. If $\frac{PaO_2}{FiO_2}$ was more than 150 mm Hg they survived.

— — — — — — — — — — — — — — —

DIVER PERFORMANCE

Glen Egstrom 20 June 1978

Psychological factors are important. UCLA developed a “Pressure Facility” in which a pressure of 0.5 psi of warm air could be achieved. The subjects were told that they could expect to be affected by narcosis at 100 feet. They were told about clearing their ears. Those who had no knowledge of the degree of stress they were being exposed to had a performance which went off with time. Those who believed they were in a stressful environment had a performance that went right off very quickly.

Learning takes practice. Two hand coordination requires 17 to 21 successful trials for good performance. Buddy breathing requires 15 to 17. Reinforcement is required. Buddy breathing 15 to 20 times during the diving course and then reinforce quarterly.

In task testing strength required, manual dexterity, position and endurance are all factors to be considered.

Environmental stress cannot be quantified but it affects performance. There is a low level of decrement (10%) in recognition (short term memory). Recall without recognition has an extra 15% decrement. Distance estimation is affected. Overestimates are made in clear conditions, underestimates in turbid water. Size estimates tend to be too large for small objects and too small for large ones. Hearing is less efficient in water than in air. Narcosis gives a definitely measurable decrement at 60 feet.

Performance decrements are envelopes on graphs not lines. Simple and well learned tasks are less affected than complicated and unfamiliar ones. Cold and carbon dioxide also change the envelope shape and position.

It is possible to adapt to narcosis, as to alcohol. Stage down 1 At a time to improve performance by adaptation.

Comparing experienced divers with novices at 2 ATA one finds that the heart rate rises more in novices. Experienced divers pace themselves so that the heart rate remains stable: 140 is fairly typical. UCLA students preparing for a dive often have heart rates over 150.

Simple movements are less affected by cold than complex fine movements. There is a predictable loss of motor function as a result of cold.

SALVAGE DIVING
Ian Lockley

Refloating stranded vessels is the majority of Salvage Pacific's work. However the salvaging of the oil from the President Coolidge involved a lot of diving.

The President Coolidge hit a mine off Espiritu Santo in the New Hebrides in October 1942. She was run onto the reef and stayed there long enough for the troops she was carrying to be got off, then she slid back into deep water. She lay undisturbed until 1967 when during the course of a survey another salvage firm removed the propellers with explosive. This blew some of the rivets and started oil pollution of the harbour. The area is geologically active so the ship gets shaken pretty regularly. In 1973 the price of oil rose and Salvage Pacific suggested an oil survey, this was carried out, then there was another big leak and P&O wanted oil in Santo. So the conditions were right for salvage.

Ian Thorn showed a film of both the survey and salvage. It is one of the best underwater films I have seen.

Some facts about the diving. The depth was 180 feet or less. The decompression were carried out in a bell which allowed the men to get out of their wet suits and sit in the dry. They winched the bell up its mooring rope in accordance with the tables. They did some 5000 odd decompression dives.
There were two type 1 (pain only) bends which both cured at 30-40 feet on oxygen. The chamber was valuable when men had to do free ascents after running out of air as they could stop 30 feet below the surface.

One observation was that on some days they could work at 180 feet, on other days they could not. There was no pattern to this and they were unable to give any reasons.

BAROTRAUMA
Ian Unsworth

Barotrauma of descent is very common. Barotrauma of ascent is usually lung damage. For this reason every diver should have a chest X-ray to exclude cysts and bullae which are absolute contraindications to exposure to pressure. Among the precipitating causes of burst lung are deliberately emptying the lungs to closing volume which leads to air trapping, asthma and other causes of airway constriction.

A clinical case of burst lung occurring during hyperbaric oxygen therapy was described. The patient had a tracheostomy and his mucus was stickier than usual leading to airway obstruction.

ENT PROBLEMS OF DIVING

Dr Bill Hurst

The common causes of nasal obstruction are septal deviation, allergy, polyps, vasometer rhinitis and infection. Polyps are usually the result of allergy or infection.

Acute sinusitis, often precipitated by a cold, inhalation of infected material or by infected teeth, requires treatment with antibiotics (Amexil, Bactrim, Tetracyclines) and decongestants. The infecting organism is often a haemophilus. If there is no improvement in two weeks antral washout should be considered.

Chronic sinusitis which gives rise to a continuous purulent nasal discharge, nasal obstruction and a headache, should be treated by operation, either an intranasal antrostomy or a Caldwell-Luc.

Sinus barotrauma. In the series reported by Fagan, McKenzie and Edmonds, there were 68 patients with barotrauma of descent and 32 with barotrauma of ascent. The common symptom was frontal pain. 50% had recently had an upper respiratory tract infection and 50% had ear abnormalities at the same time.

The best prophylaxis is not to dive. The acute phase should be treated with decongestants.

Otitis externa. Before going to the tropics one should have wax and debris removed from one's ears.

For prophylaxis he recommended Vosol, which contains acetic acid in 70% alcohol. This lowers the pH and inhibits the division and multiplication of pseudomonas. The alcohol helps dry the ear.

For treatment he recommended Sofradex, which contains Framycetin, Colistin and Hydrocortisone.

Other prophylactic drops could be used, eg. aluminium acetate, gin or vodka.

Physiology of Immersion

Glen Egstrom

NAASA published an annotated bibliography of immersion and its effects in 1974 which he had found very useful.

Immersion affects respiration. A person immersed to the neck has a decrease of his expiratory reserve volume of 11% and 20 cm underwater using apparatus there is the same effect. Breathing oxygen neck immersion reduced the vital capacity by 22% compared with air breathing control. Oxygen breathing potentiates atelectasis, which can be reduced by forced deep inspirations. Nitrogen elimination is increased with immersion to the neck. In 35°C water it is 35% more than in air, while in 37°C water it is 42% more. The rate reduces with time and the increased elimination is probably due to increased peripheral circulation.

Vail showed some years ago that there was a reduction in small airway diameter with forced expiration leading to collapse and gas trapping. Even in shallow immersion one gets gas trapping with a decrease of the vital capacity of 2%. Exercising in the horizontal position gives rise to a lesser decrease. Going from negative through the eupnoeic to positive pressure breath can negate the changes.

The breathing pattern in air is a pause after breathing out. In water the pause is after inspiration with inspiration following immediately after expiration.

Cardiovascular changes include an increase of 38% in cardiac output, with an increase in stroke volume of 25 ml (35%). Diving bradycardia occurs with face immersion. There is an increase of up to 700 ml in the central blood volume. The CVP rises. There is a bradycardia which increases with time immersed. The diving reflex, apnoea and bradycardia on face immersion is more noticeable with cold water. The forearm blood flow is decreased by 60% while the forearm resistance is increased by 40%. Although the heart rate goes down the energy cost is unchanged.

The sudden death syndrome has recently been described. Middle aged men return from a dive on the surface, are alright for a while then develop respiratory trouble and die. The post mortems have normally given the cause of death as drowning. There is speculation that what kills them is a hypertensive episode opening intracardiac shunts L-R.

Diuresis is almost inevitable. A diver working hard at 150 feet will develop a 3 to 4 pint (American) decrease in his plasma volume. Negative pressure breathing induces a diuresis of up to 500 ml/hour; diuresis subsides after 2-3 hours with individual variations. Sodium excretion is increased. Cold causes diuresis, as does alcohol. Respiratory water loss is 500 to 600 ml a day in normal air, dry gas increases the water loss. The effects of water loss in terms of performance, work capacity gas uptake, etc. is not understood. Immersion diuresis is reduced by positive pressure breathing. The diuresis varies with water temperature, fitness, age, etc.

Skin does not take kindly to being constantly wet, the diver develops pain, cannot work properly and the skin eventually sloughs.

NEW TOYS
Glen Egstrom

This was a review of various advances in diving technology.

1805 - Fullarton produced a diver’s suit which protected the areas of high heat loss.
1918 - De Graaf produced a 1 atmosphere diving system. It leaked.
1918 - Leavitt produced a 1 atmosphere diving system with articulated arms and legs. There were problems with the ends of the arms.

The USN standard diving dress Mark V is very similar to that introduced by Siebe Gorman over 100 years ago.

The Mark VIII is capable of 1000 foot depth in theory, however 600 feet is as far as it has been taken. There are two 90 cuft 5000 psi bail out bottles which give a bail out capability. This is enough for a no-stop 300 foot dive ascent. No dive to that depth is no-stop. It is a hotwater suit with an umbilical connector block weighing 23 lb. There are troubles with the umbilical - 300 feet costs $17,000. Although the umbilical was designed to weigh 1/10th of a pound per foot it has flexible walls and at 450 feet actually weighs 6/10th of a pound per foot. The helmet is buoyant and the diver is weighted on his chest and waist.

The Mark XII should have been in service two years ago. The helmet is neutrally buoyant. The diver wears the weights on his thighs which gives him better mobility. It is in its 7th year of development. The major problem is that Mark V trained divers are reluctant to learn the new skills demanded by this equipment.

One atmosphere suits have a future. The Galleotzi suit of the 1930s had limited visibility and the articulated joints leaked. JIM, the current widely used one atmosphere suit, has articulated arms which don’t leak and a large viewport in the helmet giving very good visibility.

It takes only 6 hours training to learn to operate JIM. JIM is a one man submersible which can walk. It is non-combatant. It can work in currents that immobilise a Mark V diver. It is comfortable and the life support system allows temperature control. It is highly mobile. In an emergency the operator can ditch the weights and ascend. There is no need for decompression. With all these advantages go some drawbacks. It is bulky. It is expensive. To lease a JIM cost $300,000 for six months and $500,000 for a year. It is air transportable, and the four man crew need 12 hours to prepare it for operation after it has arrived. The life support system lasts for 10 to 11 hours. It has made successful dives (working) to 1700 feet and under the icecap.

Under development are SAM, a slimmer version of JIM designed to work between 150 and 2000 feet, and WASP. WASP is a development of the idea of Lethbridge in the 18th century. It is a one atmosphere system with moveable arms but no legs. Mobility is by means of thrusters at the side. Vision is good, but the development is halted as the designers lost a patent conflict. It should be more mobile than JIM.

Most diving companies are now equipped for saturation diving (the state of the art) and are not keen on changing to one atmosphere systems. There are advantages in the new system. The operator has no need for diving experience, he only needs work skills. There will be problems with unions and divers when the 1 ATA systems become widely used especially as it is likely that the cost of the systems goes up the divers wages will go down. However it seems likely that JIM and WASP will be widely used for work below 150 feet within the next 5 to 10 years.

Dysbaric Osteonecrosis

John Knight

Dysbaric osteonecrosis is only one of many causes of osteonecrosis. It has been known to occur in compressed air workers since 1911 and in divers since 1941. It was not thought to be an important condition until the late 1960s when Walder and McCallum described the incidence in compressed air workers. Of 1694 men, 334 had definite lesions (19%). 40% of the lesions were juxta-articular, which meant that 7.6% of the men had a potentially serious lesion. 1.9% had a disability. Other series showed lower incidence, for instance the RN survey by Elliot and Harrison of 383 men had a lesion incidence of 8% and the lesions were only found in men over 30.

The Medical Research Council in the UK formed a decompression sickness panel which monitors the X-Ray films of all compressed air workers and commercial divers . Last year Dr Davidson, one of the consultants to the panel, visited Australia. In September 1977 the panel had X-ray films of 2300 compressed air workers with an incidence of 383 lesions (17%) and 2316 divers with 60 lesions (2.4%). Of the divers 804 had never been below 150 feet and were presumed to have never used helium. They had an incidence of 0.4% of lesions while the 1138 men who had been below 150 feet and presumably had used helium had a 2.7% incidence. The incidence in divers is low but this may be an artifact as the statistics for divers have not been “collected” for long.

The classification was discussed and illustrated with X-ray films. All schemes divide lesions into juxta articular (A Group) and Medullary lesions (B Group) with different sub groupings depending on the origin of the authors. The MRC group do not believe that bone islands or cystic areas are indicative of osteonecrosis, while the Japanese do. Some cystic areas clear over the years, which suggests that they are an on-going process of repair of damage.

The main problem with osteonecrosis studies is that the lesions are followed by X-rays, it is a diagnosis based on shadows which take months to appear. Experiments using glass spheres have shown that it takes over 3 months for the X-ray change to show up while the histological change is visible under the microscope in days. Not all areas damaged show the X-ray changes so the current techniques which show promise, estimation of the urinary hyxroxyproline and technetium scans (which often show areas which do not go on to X-ray change) have problems. Could one really tell a diver to give up his occupation on the basis of a urine test, only to find no X-ray changes ever developed?

The Japanese have a large experience in dysbaric osteonecrosis as they have diving fishermen who do not pay much attention to decompression. In one survey 268 of 450 divers had definite lesions (59%). The incidence was higher after 5 years of diving and in those who had been deeper than 30 metres. 73% of the men with lesions had been treated for decompression sickness. On the other hand, Sealey has reported that using the Washington State Tables his series of 86 men have only minimal bone changes in 6%, all in the youngest third of the men.

Whatever the causes of dysbaric osteonecrosis, and arterial blockage by bubbles (unlikely), gas induced osmosis (no longer favoured) and venous bubbles have all been postulated, there does seem to be an association with careless decompression. Navies which on the whole are careful about decompression have much lower incidence than other series. Sports divers used to be considered unlikely to develop the changes but in Williams and Unsworth’s paper from Sydney there were three cases in 19 sports divers surveyed. What the real incidence in Sydney sports divers is anyone’s guess as there are certain to be more than 19 such cases in Sydney.

One of the things that stands out in the literature is that the X-ray diagnosis is very dependant on personal opinion, which needs to be checked and checked again. More is being learnt about the progression and incidence, but why some lesions progress and others do not is still unknown.

Physiology of Diving Mammals

John Knight

This paper followed that by Glen Egstrom on the physiology of immersion. It was a rapid review of the various adaptations by the marine and aquatic mammals to their environment.

The diving responses which are present in all mammals are, bradycardia, vasoconstriction, lactic acidosis and anaerobic metabolism. This is normally precipitated by putting the snout under water. The advantages of these responses are better perfusion of the heart and brain, decreased oxygen needs, increased oxygen extraction, energy production without oxygen and maintenance of the core temperature. The disadvantages of diving include an oxygen debt, tissue anoxia and hypothermia. Man is an inefficient diver, his pulse rate only drops from about 75 to 40-50 while that of the porpoise drops from 60 to 30, the whale from 100 to 12-24, the seal from 70-140 to 7-14, the hippopotamus from 100 to 10-20 and the beaver from 75-90 to less than 10.

With practice all mammals can improve their performance by acquiring increased oxygen stores, increased lung capacity, and increased efficiency of ventilation, better tolerance of hypothermia and of oxygen debt, a decreased shivering threshold and better subcutaneous insulation. These allow better resistance to thoracic squeeze, increased dive duration, and tolerance of cold water.

On top of this the specialised aquatic mammals have a rounded body contour which streamlines them, lungs which collapse so that at depth the air is in the major airways, special blood vessel adaptations to allow for filling the lungs and middle ears, and changes of renal function. As their air containing spaces are able to be filled with expanded blood vessels they avoid barotrauma. As the lungs are empty of air there is no extra nitrogen uptake so they avoid decompression sickness and nitrogen narcosis. They are able to maintain cerebral perfusion, and can use the venous oxygen stores. Due to their insulation and streamlining they have better tolerance to cold and excellent swimming powers.

While man can hold his breath for 3 minutes the beaver can last 15, the porpoise six and the seals from 20 to 40 minutes depending on species. The whales are the winners, with the bottlenose whale lasting 120 minutes underwater. On the basis of predicted oxygen stores man is only marginally longer than expected, but the porpoise, which is expected to breath hold for 2.5 minutes can actually dive for 6. While the bottlenose, which should in theory last 36 minutes underwater can last 120. When we consider depths, man has recorded to 305 metres, the Weddel seal to 550 metres, the bottlenose whale to 825 metres and the sperm whales entangled with submarine cables have been retrieved from the site of the break in this depth.

Turning to respiratory function, the aquatic mammals breath much less often than terrestrial but with a much larger tidal volume. Although the aquatic mammals have less lung volume per kg body weight than man, they use it more efficiently, and have a lower oxygen usage per kilo of body weight.

<u>Clinical Decompression Sickness</u>
John Knight

Twelve cases of decompression sickness occurring on the island of Nauru were discussed. One died before decompression. Of the others treatment was successful in all except one, who had been treated two months before for pain in the shoulder and weakness of that arm. This time he emerged from two treatments a paraplegic and was then given six days hyperbaric oxygen without any improvement. He was later transferred to the Royal North Shore Hospital in Sydney, and by the time of the meeting was said to be walking again. The common feature of the Nauru cases was great depth, over 200 feet, and omitted decompression. The cause of this diving pattern is the overfishing, using scuba, of the redfish (a local delicacy) from the upper layers of the water. Now one had to go to 200 feet to find the large ones. The standard treatment in the Nauru chamber has been USN Table 5, which was in-appropriate in the presence of neurological symptoms (Table 6 should be used).

An interesting case treated at Truk during the last SPUMS Annual Conference was presented. This man presented on Sunday, having been diving on Wednesday and Thursday, omitting decompression. Following Wednesday’s dive, he got a pain in his back, which was not affected by Thursday’s dive. His main problem started on Friday afternoon, with sciatica and bladder problems. Being a true diver he treated this with beer. Although he had numbness below the knees, he continued the beer treatment through Saturday and Sunday. He had diagnosed his own condition and mentioned it to some SPUMS members. It was agreed, in consultation with the hospital authorities, to treat him at the hospital in the single man chamber. The ride of about two miles over one of the worst potholed roads in the world changed him from an ataxic with anaesthesia below mid calf into a paraplegic with a paralysed left arm. Such is the power of shaking. He was almost completely cured when he came out of the pot at 1.30 am with a residual weakness in his left leg and some minor anaesthesia of his toes. But by 9 am he was again almost completely paralysed below the waist and was retreated with oxygen. He improved but was still weak in his left leg and this worsened over the next day or so. He was not treated again as we were using oxygen to compress the pot and did not wish to expend the island's supply. No one knew when the next ship would arrive with oxygen on board. He was transferred to the USN hospital at Guam and from there to USN hospital at Bethesda Maryland where he received hyperbaric oxygen without much improvement. He has now been lost to follow up.

MINUTES OF THE AGM OF SPUMS HELD AT SUVA

Continued from page 83

The accounts had been audited by RG Goddard ARMIT AASA.

As there had been considerable expenditure after the books had closed, there was a need to increase subscriptions by $5 to $20 and $15. Proposed by Rehfisch and seconded McCartney. Carried.

Committee Elections: There being no further nominations the following were declared elected.

President	Ian Unsworth
Secretary	John Knight
Treasurer	Bill Rehfisch
Editor	D Walker
Committee members	Victor Brand
	Ray Leitch
	Chris Lowry

Appointment of Honorary Auditor: Proposed W Rehfisch, seconded J Knight that RG Goddard be appointed Honorary Auditor. Carried unanimously.

No further business the meeting closed 1930.

Exercise and the Heart: is "Norm" right?

From time to time, when the ABC is not telling us of the wonderful programs to be seen some other time, we are favoured with Norm, the last of the all round sportsmen. He sits in his chair and drinks his beer rather than going out in his car to the countryside or taking the dog for a walk. But some recent research seems to indicate that Norm is onto a good thing, way in advance of accepted teaching. A number of newspaper reports should lead him to sink deeper into his chair and take a discrete swig from his "cold tube"

First there was the report of the South Australian ministerial working party commissioned to report on physical fitness. It decided that moderate exercise such as gentle jogging, was not enough. Regular, sustained and energetic exercise, roughly equivalent to a fast singles tennis match, was necessary if benefit was desired. The effect was then equal to lowering the cholesterol level and cutting out cigarettes, it was claimed. However they added that such activity significantly reduced the risk of coronary heart disease as well as providing other health benefits. But Dr Colin Bloor, at the University of California School of Medicine near San Diego, has been trying to put this thesis into the realm of proven fact ... and come up with the wrong results. His research team had ten small pigs running in a treadmill for the equivalent of 40 km per week for one year while matched litter-mates were allowed to laze around. The treadmill pigs lost 20% of their weight in comparison with the others but although their heart efficiency improved their circulation did not. In fact it was no better than that of the lazy pigs. This has been taken to indicate that their risk of heart attack has not been reduced, a surprise to Dr Bloor and his research team, all of whom are dedicated long-distance runners. So much for exercise.

An American heart specialist, Dr Arthur Klatsky, of the Kaiser-Permanente Medical Centre in California has recently reported on the results of his studies of the ECGs of 39,479 men in an attempt to link heart disease with the use of alcohol. He told the eighth World Congress of Cardiology in Tokyo, according to the newspapers, that while regular large amounts of alcohol probably caused heart trouble in some people, abstinence could increase the risk of an attack. Compared with non-drinkers, men who had two or less drinks daily had a lower prevalence of abnormal ECG results, while compared with non drinkers those who had three or more drinks daily had no more evidence of abnormal ECGs. These findings were independent of age, smoking, coffee use, or previous "heavy" drinking.

So once more it seems that Nature likes the moderate rather than those who strive too fiercely to the differ from the norm. Which is what we wanted the Experts to find out, one may imagine!

* * * * * * * * *

NOTHING'S FOR FREE

Mr Bell, British based managing director of Shell Oil Exploration, has said that his firm is now spending $1500 a minute on their North Sea Oil operations.

A VERY LUCKY DIVER

Keith Momery, a 23 year old skin-diver, became unconscious and sank while diving off Penzance, U.K., recently. His life was saved through the action of Beaky, a dolphin well known to the local divers, who swam down and not only brought him to the surface but kept him afloat till rescuers arrived. Not everyone who dives alone can expect such providential succour.

MINUTES OF THE AGM OF SPUMS HELD AT 7 PM on Wednesday 21 June 1978 at the Tradewinds Hotel, Suva, Fiji.

Apologies: C Lowry, R Leitch, D Walker.

Present: I Unsworth, (President), J Knight (Secretary), W Rehfisch, (Treasurer), V Brand (Committee), A Balthasar, T Cairns, C Barrett, B Coyle, J Doncaster, C Friendship, R Hare, W Hurst, P Kay, J Mannerheim, P McCartney, P McCartney, A Robson, A Slark, T Swain, R Sutherland, T Trewartha, D Wallner, G Weaver, J Watson, A Newly, G Davis.

Minutes of the last meeting were read by the Secretary.

Matters arising: SPUMS Prize. No applicants by the due date.

Annual Report: The President welcomed the attendance and interest shown by members in the Scientific Conference. The Secretary presented a short report.

Downunder' 77 was not a success. The Australian papers were at least as good as overseas but there was little support from Australians and poor organisation spoilt the congress.

SPUMS, UMS and the Medical Commission of CMAS co-sponsored the First World Congress of Underwater Sports Medicine as part of Downunder 77. The secretary was not allowed any part in the organisation and had to threaten to withdraw SPUMS' participation to get any information at all.

Three other meetings have been held:

* Adelaide October 15th with 12 members attending
* Melbourne March 11th with about 30 members. This was a joint meeting with POAA. Dr David Youngblood spoke on Medical Problems of Saturation Diving. Excellent papers from both doctors and divers.
* Sydney April 8th about 30 members. A good meeting at the Roche Research Institute of Marine Pharmacology. This was followed by a dinner in Sydney.

Membership breakdown as of April 1978

Doctors	181
Engineers	1
Pro Divers	3
Medical Scientists	6
Sports Divers	1
Diving Instructors	1
Others	8
Total:	**230**

The Annual Scientific Conference was in progress with Dr Glen Egstrom, Professor of Kinesiology at UCLA as the guest speaker. Both diving and science were good value.

Once again there had been a poor response to calls for nominations. Only the present committee nominated. No business had been offered for the AGM to discuss

Treasurer's report.

Summarised as

Cash in hand 1 May 1977	3004.94	
Income	3920.09	
	$ 6925.03	
Expenditure	2586.48	= remaining 4338.55

continued on page 81

Physiological Concerns of Women Scuba Divers

Susan A Bangasser, NAUI 3910, California

Many women now enjoy the sport of scuba diving. The number of women certified from the basic diver through instructor levels is continuously increasing. Yet many women divers experience anxiety over participating in some scuba diving activities due to personal problems. For example, can a female dive in the ocean when she is having her menstrual period? Most scuba classes don't touch on these subjects and most female students are reluctant or embarrassed to ask the instructor. Furthermore, this is not a very popular topic for diving magazines, since the majority of their readers are male. I will cover most of the physiological areas that are of concern to women divers. These areas include diving in thermal comfort, diving during the menstrual period, diving while using birth control pills, and diving during pregnancy.

Thermal Comfort

The first subject, diving in thermal comfort, covers the sensitivity of females to cold and hot conditions. Women have a layer of subcutaneous fat which acts to retain body heat because of the low thermal conductivity of fat. This has been shown to be an asset to the Ama divers of Korea. However in my experience as an instructor, many female divers suffer from diving in cold water sooner than their male colleagues. As recent study indicates that there is indeed a physiological basis for this phenomenon. In considering an individual's sensitivity to cold, two factors must be considered: (1) the degree of body fatness, and (2) the ratio of surface area to body mass.

Lean women (less than 27% body fat) have a large surface area to body mass ratio and therefore cool at a faster rate. Above a fatness of 30%, men and women maintain similar low levels of heat production when placed in cool water. To solve this problem, anyone who cools easily should invest in an adequate and properly fitting wet or dry suit. If uncontrollable shivering begins, get out of the water.

Sensitivity to heat is important to divers carrying heavy gear and suiting up during the hot summer months. The female's body temperature will rise 2° to 3° higher than the male's before the cooling process of sweating begins. Also, the female has fewer functional sweat glands. The solution to this problem during prolonged periods of very strenuous activity is to periodically cool off. A dunk in the water before donning one's tank and weight belt usually is easy to do.

Menstrual Period

Another area of concern to women is diving during the menstrual period. Whether a woman should dive during this time depends on just how well she feels. If the diver feels fine, go ahead and dive. In the Olympics of 1972 and 1976, female medal winners were at all stages of the menstrual cycle. The menstrual period did not prevent top performances by the athletes. If however, severe cramps or discomfort are experienced, the woman should postpone her diving. One complication of the menstrual period is fluid retention. Oedema may make a woman more sensitive to decompression sickness. Females should follow conservatively the No Decompression Table of the Navy Diver Tables, if diving three days prior or during her period.

Women who dive in salt water during their period frequently ask, "What about the sharks?" The average blood loss during a period is 25 to 70 cc, over three to four days. Internally worn protection, eg. a tampon, is preferable to an externally worn napkin. There is no evidence of increased shark interest in a menstruating female, so the woman diver should concentrate on the other factors of her dive and enjoy herself.

Birth Control Pills

The third area of discussion is that of diving while using birth control pills. First, I would like to cover the possible susceptibility to decompression sickness of women in general. Decompression sickness has been studied in nurses undergoing flight training at the United States Air Force School of Aerospace Medicine. Much of the work was done by Dr Bruce Bassett, Major, USAF, from 1968-1972. During these five years at the USAF SAM, there were nine cases of decompression sickness out of 12,246 exposures. The females had a ten-fold greater incidence than the males undergoing the same exposures. More recent studies have verified the increased incidence of decompression sickness in women over men undergoing flight training. As a result of these studies, flight nurses are now exposed to different altitude chamber flight profiles. Some observations were made at this time of the characteristics of decompression sickness in nurses. The onset of the bends was four to eight hours after reaching ground level. Also, many of the reactions were similar to migraine headaches with neurological findings, and a prodrome of acute anxiety occurred. Factors that are postulated to increase one's risk of decompression sickness are the following: history of migraine headache, use of birth control pills, fluid retention during the menstrual period, severe dieting resulting in some vitamin deficiencies, and anaemia.

The female scuba diver should therefore be aware of the possibility of increased risk to decompression sickness if using birth control pills. To avoid incidence of the bends, I recommend avoiding decompression dives, avoiding "deep" dives, and using the No Decompression Table conservatively (ie. stay at a particular depth less than the time indicated). The women scientists in the Tektite II project discontinued use of birth control pills three months prior to their saturation dive to avoid any increased chance of decompression sickness.

Risk to Foetus

A final concern of women divers is the possibility of risk to the foetus due to scuba diving during pregnancy. Is there any chance of harming the foetus due to changes in the partial pressure of oxygen (pO2) or due to nitrogen bubble formation? Research has been done on mammals on the transfer of gases across the placenta. Oxygen transfer to the foetus across the placenta must be rapid and continuous to assure successful growth. There are special mechanisms that assist the foetus in transplacental oxygen exchange:

(1) higher haemoglobin concentration in the foetal blood, increasing its oxygen carrying capacity, and
(2) higher affinity for oxygen of the foetal haemoglobin.

Only severe hypoxia in the mother will cause changes in the foetal oxygen content. The placenta prevents transient fluctuations in foetal blood pO2.

Scuba divers, however, must be concerned with increasing pO2 and the possibility of subsequent increased pO2 in foetal blood. In experiments on gravid ewes, the maternal arterial oxygen tension was increased by providing 100% oxygen at one atmosphere. (This pO2 is equivalent to breathing air at a depth of 132 feet of sea water). There was only a very small increase in foetal blood pO2. In sheep, cow, pig, and primate, only small changes occurred in foetal blood pO2 when maternal oxygen intake was increased. In contrast, an experiment on rats did demonstrate foetal wastage with hyperbaric oxygen.

In most of the animal studies foetal oxygen content remained relatively stable during significant maternal pO_2 increase. Also there appears to be differences in placental gas transfer between different groups of mammals.

Another consideration of the pregnant scuba diver is that of nitrogen absorption and elimination. The gas nitrogen does not play a significant role in sustaining the life of the foetus. Therefore, exchange of nitrogen through the placenta during a dive probably depends on the tissue half time of the foetus, just like other tissues of the body. After a deep dive or prolonged dive to moderate depths, rapid reduction of ambient pressure can cause nitrogen bubble formation. The presence of these nitrogen bubbles in the foetus can cause serious destruction.

The pregnant diver therefore has to consider two areas that are possibly hazardous to the developing foetus, increased pO2 and nitrogen bubble formation. The research on mammals and pO2 elevation in the foetus is reassuring. However, humans have not been studied and the effects of minor increases in foetal pO2 are not known. The pregnant diver can continue to enjoy the underwater environment but should extend her prenatal care to include limiting the depth of her dives. I recommend depths of 33 feet or less, to avoid even the possibility of problems due to increased pO2 or to nitrogen bubbles.

Summary

The information presented here may help answer some questions women may have had about their own physiology and its relation to safe and enjoyable scuba diving. In essence, common sense prevails if a question arises about the safety of the scuba diver.

(Reprinted from the *IQ9 Proceedings*)

* * * * * * * * *

PREGNANT DIVER UPDATE

Susan A Bangasser
NAUI 3910, California

The safety of diving while pregnant is a topic that has only recently been investigated. Although there has been much speculation on the subject, very little data is available. Animal studies are being conducted and the information they provide will hopefully be applicable to humans.

In order to gather data on this subject and other related medical areas on the woman diver, I began distributing a survey in the fall of 1977. This was entitled the Medical Aspects of Women Divers Survey. About 680 responses were analysed and of these, 72 respondees dived while pregnant (10.5%). This number included women who made even one dive while pregnant. If the woman quit as soon as she discovered she was pregnant, but had made a dive in the first six weeks, she was included in these results. Twenty-two women stated they did not dive while pregnant; apparently they made no dives prior to being diagnosed as pregnant and then decided not to dive.

Now let us look at the pregnant diver. Thirty-nine percent quit diving during the first trimester (the first three months), usually as soon as she learned she was pregnant. Most of the women (41%) discontinued diving during the second trimester, about the time when increased size becomes a problem. Twenty percent dived during the third trimester. Only seven women continued to dive through the ninth month. Most of the respondees were seasoned divers, with six years as the median (most frequent) number of years diving. Forty-one percent were certified as Basic Scuba divers, 14.5% were Instructors, and the remaining had intermediate levels of certification. The diving activity of the women before, and or after becoming pregnant was as follows: 22% dived at least once a week, 49% dived six to twelve times a year, 25% dived on vacations only, and 4% seldom dived. During pregnancy the diving activity of the women consisted of 20% diving at least once a week, 18% six to twelve times a year, 34% on vacations only, and 28% seldom. These diving activities .were maintained, of course, until the women chose to discontinue diving altogether. Only 28% of the women stated they dived with the same frequency during pregnancy as before pregnancy. The number of women who dived at least once a week remained fairly constant. Most of these women dived in the very warm waters located at diving resorts, and several of them worked as instructors or tour guides. Pregnant women apparently still go on vacation and enjoy the warm, clear waters. There was a large increase in the seldom-dived category.

The potential problems associated with diving during pregnancy includes the possibility of the mother and/or foetus getting decompression sickness. The nitrogen bubbles in a developing foetus could pose serious problems for the foetus (retrolental fibroplasia). Five of the respondees made decompression dives while pregnant. However, no pregnant diver had decompression sickness. The maximum depth obtained by the pregnant diver ranged from 12 to 180 feet, while the median was 60 feet maximum. The average depth ranged from 10 to 100 feet, with a median of 40 feet.

The temperature of the water dived in ranged from 40 to 80 degrees, with most dives made in 70-80 degree water. Women did not avoid diving with wet suits; 48% wore wet suits. However, fitting into the wet suit was one of the problems contributing to the decision to discontinue diving temporarily.

MOTHER-TO-BE-OR NOT TO BE.
THAT IS THE QUESTION!

continued on page 98

HEALTH AND SAFETY EXECUTIVE RECOMMENDATIONS ON MEDICAL EXAMINATION OF DIVERS (UK): INFORMATION FOR EXAMINING DOCTORS

The United Kingdom's Health and Safety Commission's Executive is preparing proposals for a unifying Code of Diving Regulations covering all diving operations, whilst at work, both offshore and inshore, but not sport or amateur diving. It is proposed, under the Regulations, to require medical examinations of divers to be carried out in accordance with the requirements of the Executive's Director of Medical Services. Recommendations have, accordingly, been prepared for doctors carrying out diving medical examinations, the objective being to ensure a high and consistent standard of medical exanimation. It is thought that (doctors outside the UK) will be interested in seeing the recommendations and their views will be of interest to the Commission. (Dr ES Blackadder, Deputy Director of Medical Services, Health and Safety Executive, Baynards House, 1 Chepstow Place, London W2 4FT).

Introduction

1. The Health and Safety Executive, following agreement among interested departments, is preparing a unified Code of Diving Regulations under the Health and Safety at Work Act 1974, to cover all diving within Great Britain and on the UK Continental Shelf. The unified Code when introduced would allow the Diving Operations Special Regulations 1960, the Submarine Pipeline's (Diving Operations) Regulations 1976 and the Offshore Installations (Diving Operations) Regulations 1976, to be revoked. One consequence of this would be that doctors "appointed" and "approved" to carry out diving medical examinations under the respective Regulations would have to be considered for reappointment under the new unified Regulations.

2. This offers a timely opportunity to issue guidance to doctors appointed under the new Regulations to ensure that sound and consistent criteria of medical fitness for diving apply at all examinations. The standards set out in this paper have been prepared with these objectives in view.

3. It is difficult to lay down absolute standards for some aspects of diving medical examinations and best current practice has been followed throughout the recommendations. On-going research may affect some aspects and the recommendations will be up-dated when necessary.

4. The recommendations deal with specific aspects of diving medical examinations, but the examining doctor's clinical opinion on fitness or unfitness should be formed on the whole of the medical examination. The section of paper on "The Medical Examination" opens with general advice to doctors conducting diving medicals to be specially sensitive to the potentially serious effects of minor illnesses in divers and to the need to assess the possible repercussions of episodes of past ill health.

5. Under the unified Code it is proposed* that divers must have log-books with an identification photograph and specimen signatures, and a section specially designed for entries showing the findings of each medical examination. The diver will have to produce his log-book for the diving superintendent before he dives and for the examining doctor when he reports for medical examination. The purpose of log-book entries is to prevent, as far as possible, an unfit diver from continuing to dive, thus endangering his own life and the lives of those working with him. If a diver loses his logbook his ensuing medical examination will be conducted as if it were an initial diving medical examination without the benefit of a written record of previous examinations and/or diving experience.

6. Any medical unfitness which debars a diver from his occupation temporarily or permanently is a most serious matter where employment is highly lucrative but often of limited duration, and where it would be very difficult, if no impossible, to find suitable alternative work. Where an examining doctor is in doubt about the medical fitness of the candidate he should obtain a further opinion from another doctor approved to carry out medical examinations under the Regulations or from a specialist on any specific medical aspect of the case, in the first instance. Where a candidate is declared unfit he should be informed that he may appeal to the Director of Medical Services, Health and Safety Executive, for a final ruling.

7. A diver who wishes to appeal will do so on an approved form which will record the findings of the medical examination and provide for a statement from the diver of his grounds for appeal. After scrutinising all the relevant documents, and ensuring that the appeal is neither frivolous nor unreasonable, the Director of Medical Services will take the advice of consultants on appeal. At least one consultant must be experienced in hyperbaric medicine and, where appropriate, one must be a specialist in the area of medicine relevant to the appeal. The Director of Medical Services will convey the findings of the appeal to the diver and to the examining doctor. Appeals will be dealt with as a matter of urgency at all stages.

Medical Standards

9. The following bodily systems should be evaluated from the history and examination. Where relevant, numerical values are given.

   The standards shall apply to all divers but certain groups of divers may require less frequent long bone x-rays as outlined in paragraph M(i).

Age

A. The minimum age for a diver subject to the provisions of the Health and Safety at Work Diving Regulations is 18 years. There is no upper age limit for diving providing all the medical standards can be met. Serious consideration must be given however to the need for divers over the age of 40 to have adequate reserves of pulmonary and cardio vascular fitness for use in emergency, and therefore to the possibility of a professional diver’s career having to be terminated on these grounds.

Obesity

B. Obesity is a particular hazard to divers and may also imply a lack of physical fitness. Any diver over 20% in excess of his recommended weight based on height/age tables (see ANNEX) should be disqualified from diving until he has lost sufficient weight. In general a figure of less than 15% in excess of the recommended weight should be aimed at. It should be noted that the tables in the Annex do not allow for variations in body type and examining doctors will wish to take this into account.

Respiratory System

C. i) Particular attention must be paid to any condition that might cause retention and trapping of expanding gas in any part of the lungs during decompression.

ii) The following conditions will automatically disqualify:
   a. Any chronic lung disease, past or present.
   b. Any past or present evidence of obstructive airways disease (eg. asthma, chronic bronchitis, allergic bronchospasm.)
   c. Any history of spontaneous pneumothorax, perforating chest injuries or open chest surgery.
   d. Any fibrotic lesion of the lung that may cause generalised or localised lack of compliancy in lung tissue.

iii) A large plate postero-anterior chest x-ray shall be normal

Cardiovascular System

D. i) There must be no evidence of heart disease and any arrhythmias must be fully investigated.

ii) Ideally the resting blood pressure should not exceed 140/90mms Hg.

iii) An exercise tolerance test should be carried out. It is suggested that the Army Physical Fitness Test be adopted but other equivalent tests are acceptable. The candidate should be required to step, at a rate of 30 times per minute onto a height of 17 inches (43.14 centimetres) for five minutes. A standard of Sum of Pulse Counts should be applied 30 second pulse counts (P1, P2, P3) are taken at 1 minute, 2 minutes and 3 minutes post-exercise. P1, P2, P3 are then added together and a test score of 190 or less should be taken as the indication of fitness.

Central Nervous System

E. i) A full examination of the central nervous system must show normal function, but localised minor abnormalities such as patches of anaesthesia are allowable provided generalised nervous system disease can be excluded.

ii) Any history of fits (apart from childhood febrile convulsions), intra-cranial surgery, blackouts, severe head injury involving more then momentary unconsciousness or concussion, and migraine, should be cause for rejection. If the severity of head injuries is in doubt, any further opinion should include an EEG examination. A history of repeated headaches should also be a cause for further investigation.

iii) Any past or present evidence of psychiatric illness should be cause for rejection unless the examining doctor can be confident that it is of a minor nature and unlikely to re-occur. Particular attention should be paid to any past or present evidence of alcohol or drug abuse.

Musculo-skeletal

F. Any impairment of musculo-skeletal function should be carefully assessed against the general requirements outlined in paragraph 8.

Ears, Nose and Throat

G. i) Both tympanic membranes must be intact and mobile when a Valsalva test is carried out. This test should confirm patency of the Eustachian tubes.

ii) Any evidence of chronic outer or middle ear discharge must be cause for rejection.

iii) Any evidence of chronic or recurrent sinusitis, catarrh or severe allergic conditions of the respiratory tract should be cause for rejection.

iv) Any history of middle ear surgery (including tympanoplasty) should be referred for specialist opinion before any decision is made.

v) Any evidence of deafness - see paragraph M(v).

Alimentary System

H. i) Peptic ulceration should be a cause for rejection unless there is endoscopic evidence of healing and the candidate has been asymptomatic for at least one year.

ii) Any abdominal herniation should be a cause for rejection until satisfactory treatment has taken place.

iii) Any other chronic gastro-intestinal disease (eg ulcerative colitis, cholelithiasis) should be cause for rejection.

Skin

I. i) There should be no evidence of chronic or acute skin disorders such as are likely to be affected adversely be friction from dry diving suits, prolonged immersion or prolonged exposure to the high humidity, elevated temperature environments which are commonly encountered in saturation diving.

Vision

J. i) The following visual acuity standard should be the minimum acceptable:

Uncorrected distant:	R 6/36; L6/36; both eyes 6/24
Uncorrected near:	R J16 (N24); L J16 (N24)
Both eyes:	J15 (N18)

ii) Visual fields should be normal on simple testing.

iii) Fundi should be normal.

iv) Colour vision should be tested at initial examination and candidates be informed of any abnormalities which should also be detailed in their log-book and certificates of fitness.

General

K. i) Clinical anti microscopical examination of the urine should be performed at the initial examination and repeated by accepted dipstick technique subsequently. Glycosuria calls for investigation before acceptance. Alburninuria may be innocent, but acceptance should only be considered after 24 hour protein excretion studies

ii) A full blood count and test for Haemoglobin “S” must be carried out at the initial examination. The sickle cell trait is more common in certain ethnic groups and evidence of its presence should be cause for rejection. At the initial examination and every subsequent examination Hb of less than 12.0G and a Pcv of less than 40% should because for rejection pending further investigation.

iii) Any speech defect which might prevent instant, clear communication with or without stress must be a cause for rejection.

iv) Severe varicose veins must be a cause for rejection. Varicose veins are not a cause for rejection if treated.

Dental

L. i) Candidates should have a high degree of dental fitness and any abnormalities of dentition or malformation of the mandible likely to impair the candidate’s ability to securely and easily retain an unmodified diving equipment mouthpiece should debar.

ii) Removable dentures should not be worn when diving.

Special Tests

M. i) Long bone and joint x-rays X-rays of long bones and joints, taken in accordance with the recommended MRC Decompression Sickness Panel techniques, should be carried out on all divers at initial examination. Such examinations should then be carried out annually, if appropriate, considering the diver's experience over the previous three years, with the following exceptions:

a. 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 30m sea-water and whose total exposure time on any single occasion has never exceeded four hours.
b. X-rays at intervals of three years will suffice for divers using only compressed natural air who have not been exposed to pressures greater than the equivalent of 50 metres sea-water and whose total exposure time on any single occasion has never exceeded four hours.
Therapeutic compression for a decompression illness will exclude divers from the exemptions set out in categories (a) and (b), above for three years.

ii) ECG Examinations

a. All divers should have a resting standard 12 Lead ECG at initial examination and annually after the age of 35 years.
b. Post-exercise or stress ECG's should be at the discretion of the examining doctor.

iii) Pulmonary Function Tests

a. All divers have annual pulmonary function tests to establish Forced Expiratory Volume at 1 second (FEV_1) and Forced Vital Capacity (FVC).
b. An FVC of less than 3.5 litres and an FEV/FVC ratio of less than 75% at the pre-employment medical examination and 70% at subsequent examinations are causes for rejection unless further pulmonary function testing reveals no abnormality.

iv) Audiometry

Annual Audiometric examination should be carried out where indicated by past history of noise exposure, barotrauma, decompression sickness affecting the ear or deafness.

A hearing loss in either ear of 35 dB or more at frequencies up to 3000Hz and 50 dB or more at frequencies above 3000 Hz is an indication for referral of the candidate to a specialist for further opinion, unless the examining doctor is convinced that such hearing loss is unlikely to be significantly increased by continuous diving activities.

Frequency of Examinations

N. i) All divers must have examinations at intervals not exceeding one year.
ii) Any illness or injury resulting in inability to dive for a period exceeding seven days, or any absence, for other reasons, from diving for a period exceeding ( ) weeks shall require renewal of the certificate of fitness to dive after such re-examination as is considered necessary by the examining doctor. In addition, any diver sustaining a decompression illness resulting in neurological or vestibular manifestations, even though therapy appears to have been successful, must be medically examined before resuming diving.

Diving Restrictions

O. i) The examining doctor may for reasons of age or other factors revealed by medical examination elect to impose limitations as to the duration and depth to which a diver may dive or the length of validity of the certification of fitness to dive.
ii) Any such limitations must be clearly identified on the certification of fitness to dive.

Log-Books

P. i) In addition to the details which are recorded on the medical examination form, the results of the examination will be recorded in the diver's log-book together with dates of chest X-ray examinations, bone and joint x-rays, audiometry, haematological, ECG and other special examination.
ii) The examining doctor will make an entry in the log-book as to the fitness of the candidate to dive and any restriction that he may wish to impose.

* *All references to proposals under the Code must be read with the reservation that the proposals are subject to amendment after the consultation process which the HSE will be carrying out on the draft unified Code.*

* * * * * * * *

Some talk of Fitness to dive! - Brief Report

There is increasing interest nowadays in obtaining a positive Medical Fitness to Dive assessment before starting training, a truly adverse verdict being accepted as a regrettable but necessary fact of life by the applicant concerned. While de facto many divers, even among the most exalted, would not pass a strict application of the highest standards put before the diving population, nevertheless there are a few points on which opinion is unanimous that diving is both inadvisable and irresponsible. It is against this background of opinion that the following facts are presented for discussion.

The witness first saw the diver when she attended for a Diving Medical. As she was on steroids, antihistamines, Ventolin and nasal drops for her exercise-induced Asthma, hay fever and sinus problems. She was advised that she was NOT fit. Another point was that there had been an unsuccessful attempt to descend on a previous occasion which had been terminated because of aural barotrauma which included a perforated drum. She was next met about 9 months later when both were in a dive trip party. She had apparently completed training from an Instructor, having "absolved" him from blame in case of accident. As a precaution, or sop to conventional concepts, she always restricted herself to slow descents, days with perfect weather and current conditions, and a fixed rule of wearing a buoyancy vest which she inflated after surfacing. She always waited to be picked up by the Safety boat, never making any attempt to swim back to it. The witness observed that she was having to make great efforts, contorting her body in great spasms, in her (unsuccessful) efforts to "clear" her ears: minor ear barotrauma occurred on this occasion and she managed to once more rupture an ear drum on a later occasion. She is said now to have been weaned from oral onto inhaled steroids but to be continuing on large doses of antihistamines and to be investigating the possibility of having an operation on her Eustachian tubes to improve her ability to "clear".

Question: how far are we "our brother's keeper".

(Taken from "Stickybeak" non-fatal incidents files)

Comparative Respiratory Physiology of Diving in Man and Dolphin

Deneice L Van Hook (NAUI 4602, Alabama)

 (The term 'dolphin' is used to refer to the Atlantic Bottlenosed Dolphin, Tursiops truncatus, unless otherwise specified).

....

Marine mammals in general, but specifically the dolphin, because of his intelligence and his friendship with man, have always spurred an interest, if not a fascination, with their freedom and their obvious enjoyment of their marine habitat. Perhaps it was this fascination that first led man to try entering the ocean and swimming in its depths. It did not take long for man to realize his limitations as a diver, and to see the effects of pressure on his body, a body that is adapted to a terrestial existence.

What is it that allows the dolphin, a warm blooded, air breathing mammal, like ourselves, to dive to depths of 300 meters, or to stay submerged for fifteen minutes, while most of us, as breath-holding divers, are limited to a maximum of 30 metres for a few brief moments?

Ever since the dolphin returned to the sea, time and nature have worked to provide him with several anatomical and physiological adaptations to facilitate his existence in his marine environment. Many changes have been made but we will concern ourselves here with only those changes which have helped the dolphin to become a better diver.

Dolphin Respiration

Let's begin by looking at the way in which the dolphin breathes. Breathing is done through the nose as in man, but the external nares or nostrils of the dolphin have migrated to the top of the head, to a position directly above the internal nares, thus he has a built in snorkel, known as the blowhole. The blowhole is closed by a dense fibrous mass called the plug, with a relaxation of surrounding musculature. During normal swimming, the dolphin surfaces about two to three times every minute to "blow". The blow consists of a complete exhalation and inhalation taking about 0.3 seconds. During this time, the dolphin exchanges about 80% of his air volume at a flow rate of 30 to 70 litres per second. This is compared with man who exchanges only about 20% of his air volume on the average of fifteen times a minute. Thus, though the pulmonary capacity of man and dolphin are not appreciatively different, the dolphin has a much greater tidal volume. Between each blow is a 20 to 30 second apneustic plateau where the breath is held.

Breathing is not an unconscious activity in the dolphin, as it is in man, but in fact, when anaesthetized, the breathing reflex is one of the first to disappear, even before adequate surgical anaesthesia is reached. Respiration must be assisted in the anaesthetized animal or death will result.

Inhalation is an active process while exhalation is a passive one; that is, it takes an expenditure of energy to inhale but exhalation requires little or none. This is due to a large amount of elastic tissue present in the lungs and diaphragm, giving them an elastic recoil when inflated, much like that of a stretched rubber band. The dolphin is however capable of forced expiration.

This style of breathing accomplishes several things. With the greater volume of air exchanged, more oxygen is obtained more rapidly. Also, water and body heat which are lost through respiration are conserved by the fewer number of exchanges per minute. In fact, heat lost through respiration, is cut to 10 to 30% that lost in terrestial animals.

Diver Respiration Problems

These are several problems which confront us as breath-holding divers, which do not appear to affect the dolphin. These include thoracic, middle ear, and sinus squeeze, as well as anoxia seen with prolonged submersion, and the possibility of the bends with repeated deep breath-hold diving. Let's look at each one of these problems individually and see what happens in man, and then how it is that the dolphin is not similarly affected.

First, the squeezes. According to Boyle's Law, as we descend, pressure increases and volume decreases proportionately. Since fluid portions of our bodies are relatively incompressible it is mainly the air spaces with which we must be concerned. These include the lungs, sinuses and middle ear primarily. At depths of around 30 meters, the air volume in our lungs, assuming a full inspiration before descent, is usually equal to the residual volume, or that point at which no more air can be consciously forced out of the lungs. The remaining air is just enough to fill up the dead air space. Descent beyond this point means that with the increasing pressure the air volume, and the remaining space must be filled with something. This something usually begins in the form of engorgement of thoracic blood vessels as much as possible, and is continued by a leakage of fluid and blood from the vessels into the alveoli of the lungs. This fluid in the alveolar spaces is called pulmonary oedema, and reduces the efficiency of the lungs by decreasing the functional area. If severe, this can result in dyspnoea, or difficult breathing, and even in respiratory failure due to anoxia.

Why is it that the dolphin is not bothered by thoracic squeeze during dives to depths of 300 metres, when his lung capacity is not significantly larger than that of terrestial mammals. In fact, it has been shown that the volume of air in his respiratory passages at 300 metres is only about 200 to 300 ml, much less than his calculated residual volume. Actually, several factors contribute to this ability. The thoracic structure of the dolphin allows for much greater pulmonary collapse than that of man. The dolphin has four pair of floating ribs where man has only two pair. These ribs are not attached to the sternum and so allow for greater thoracic flexibility. The trachea and bronchi of the dolphin are equipped with an extensive system of cartilaginous support, but they are arranged to allow for flexibility.

BLAST THAT FISH!

Alf Leggatt, who was awarded the NBE for his services to fishing, asked the army to blow a perch out of his pond because i had eaten 2000 goldfish there. The army obliged and exploded two charges. But the perch stayed put. Nicknamed "Jaws" to commemorate his appetite, he remained an unwelcome victor. His reign only closed when the Southern Electricity Board sent two men to shock him. They used an electrified fishnet, 20 minutes and 240 volts to complete the assignment. As Alf said when his enemy floated stunned to the surface, "I knew I'd get him in the end - I wouldn't let a thing like this beat me. But I must admit I've developed a grudging respect for him". So he put Jaws, all of 31 cms long, into a separate pond in front of his house. Jaws quickly recovered and swam strongly round the pond.

"He looks hungry," said Al.

(UK News reprint)

The trachea has been shown to be capable of dorso-ventral collapse when exposed to increasing pressure. The diaphragm is also well developed and capable of a great deal of flexibility. The lungs contain a large amount of elastic tissue which allows extreme collapse without trauma. The lungs are actually capable of almost complete atelectasis, or collapse, without being torn away from the thoracic wall. With collapse of the trachea, bronchi, and other respiratory passages to the full possible extent, only the bony portions of the nasal passages remain fully inflated, with a volume of 50ml, much less than the 200 to 300 required for the 300 metre dive.

The lungs are provided with a rich supply of large distensible veins which are seen to engorge with increased pressure of diving, and thus assist in filling some of the dead air space. Extensive thoracic and vertebral vascular networks called retia are present and capable of engorgement to prevent complete collapse of the trachea.

Middle ear squeeze in man is seen on descent when, again according to Boyle’s Law, the volume of air in the middle ear is reduced and the remaining space requires filling up with something. In this case, the space may be filled with water, when the flexible tympanic membrane is stretched beyond its limit and it ruptures. Middle ear squeeze and rupture of the tympanic membrane is prevented in man by allowing air to pass up the Eustachian tube to equalize the pressure on both sides of the tympanic membrane, in the dolphin, Eustachian tubes exist for this purpose and it is believed that he uses a modified Valsava technique for equalizing his ears on descent. Numerous venous plexuses also exist in both the middle ear and the air sinuses of the head which can engorge to prevent ear and sinus squeeze.

Anoxia, or lack of sufficient oxygen to maintain consciousness, is a problem encountered as man attempts to stay underwater for any extended amount of time on one breath of air. Anything in excess of a few minutes, and most individuals will become unconscious. The dolphin, on the other hand, makes routine dives for five minutes at a time and can stay under for fifteen minutes and sometimes more without suffering any ill effects. How? It’s not a simple matter of, “He can hold his breath longer”, or “He doesn’t need as much oxygen,” but is instead, a complicated mixture of anatomical and physiological adaptations of the cardiovascular and respiratory systems.

Cardiovascular adaptations are numerous. The blood itself has undergone certain changes. The volume of blood has increased, as well as the haemoglobin concentration, and the packed cell volume, or percentage of red blood cells to serum. This allows for a greater oxygen carrying capacity of the blood. The mean corpuscular volume has also been increased, thus the surface area of the red cells has been increased 1.5 to 2 times that in terrestial mammals. This permits rapid absorption and release of oxygen, allowing for rapid oxygen transport to the tissues. Another cardiovascular adjustment involves a widespread peripheral vasoconstriction which is seen during diving. This vasoconstriction is not confined to the capillaries alone, but effectively results in a shunting of blood away from the peripheral circulation and to the more vital organs of the heart, liver, and brain. Thus oxygen is conserved for essential life-preserving processes. Shunting of blood away from the outside of the body and appendages also assists in the preservation of body heat, a constant struggle for the warm blooded dolphin.

A diving bradycardia, or slowing of the heart rate is seen in the dolphin as well as other diving mammals. Man, and even non-diving mammals show a similar bradycardia upon submersion. The slowed rate is more evident in the deeper diving mammals such as the seals, and deep diving whales. The exact mechanism which initiates this reflex is not known. It is primarily the result of an extension of diastole, or the resting phase of the cardiac cycle. Though the heart rate slows, the blood pressure remains about the same. A similar bradycardia can be seen in the anaesthetized dolphin which is suffering from anoxia, but is not seen if the animal is properly ventilated. A normal respiratory arrhythmia has been noted, with the heart rate increasing to 70 to 120 just after inspiration and dropping to 30 - 60 quickly thereafter; maintaining that rate until the next breath is taken.

A so called “natural aneurism” or bulbous dilatation of the ascending aorta has been noted just distal to the left ventricle. It has been postulated that this dilatation, with its extensive supply of elastic fibres, may serve as an assist to the coronary blood flow and maintenance of arterial pressure during the long diastole seen with diving bradycardia.

The value of the lung air as far as increasing blood oxygen levels during diving is, at best, of little value, in fact, in deeper dives, alveolar collapse precludes any pulmonary gas exchange. What this means is that reserves must exist elsewhere, or that anaerobic respiration must take place, especially in those tissues which are essentially cut off from the main circulatory system by the widespread vasoconstriction seen with diving. As it turns out, the dolphin can store a great deal of oxygen in the muscle tissue bound to the muscle form of haemoglobin., or myoglobin. Myoglobin can be responsible for up to 50% of the total oxygen stores. In addition, the muscle tissue can function anaerobically, when its oxygen stores are exhausted. This builds up a so called oxygen debt which must be repaid upon surfacing. After a period of prolonged submersion, the dolphin must surface and by means of several exchanges of air, repay any oxygen debt he has accumulated. The vasoconstriction is relieved on surfacing and the oxygen rich blood is carried to the muscle tissue to complete the required aerobic portion of sue **respirati**on.

In addition to these cardiovascular changes, several respiratory adaptations have been made. The dolphin has higher tolerances for both oxygen debt and carbon dioxide excess. In man, one of the more sensitive signalling devices of the brain to initiate breathing is an increase in the partial pressure of carbon dioxide in the blood. This effect can be lessened somewhat by hyperventilation, where carbon dioxide is blown off to such a low level that the decreased level of oxygen in the blood takes over as a secondary signalling device. Hyperventilation has also been noted in the dolphin, but is not the sole method for suppressing the carbon dioxide signal. There is actually a naturally decreased sensitivity of the brain to carbon dioxide, so the urge to breathe is not as strong, and in fact the need to breathe is not as immediate as in man with similar blood carbon dioxide levels.

Dolphins and Bends

Why don’t dolphins get the bends? The bends, or decompression sickness, is in general thought to be associated with compressed air or SCUBA diving, but it has been shown to occasionally result from repeated, deep, breath holding dives. In this case, continued repeated compression of the alveolar air with resulting high partial pressure of nitrogen in the blood. Upon ascent this nitrogen in solution comes out of solution and bubbles into the tissues, especially the joints, causing pain and other associated signs of the bends. This disease has not been reported in dolphins even following as many as ten dives to 260 feet within a one hour period.

The reason why dolphins don’t suffer from the bends is related to the anatomy of the lungs. From eight to ten discrete circular myoelastic bundles are present in the terminal bronchioles, or the small air passages leading into the alveolar sacs. These act as sphincters to compartmentalise the bronchiole. They serve as valves between the high pressure air in the trachea and the low pressure maintained in the alveoli during diving. They break up this large pressure differential into several small pressure differentials. These sphincters do not trap air in the alveolus, but instead actually trap air away from the alveolus, and this away from the area of gas exchange. By maintaining low air pressure in the alveolus, the partial pressure of nitrogen is not driven into solution in the blood in significant quantities to result in the bends.

Thus we can see that nature has provided the dolphin with many and varied adaptations to facilitate his marine existence, just a few of which are mentioned in this article.

Summary

Nature has marvellously adapted the dolphin to his environment. These adaptations include many anatomical and physiological changes. The thoracic structure can collapse without permanent damage, almost to the point of complete atelectasis. This is due to a large supply of distensible veins, elastic pulmonary tissue, and flexible bronchi, trachea and rib cage. The blood has a greater oxygen carrying capacity than that found in land mammals. The muscles are capable of storing up to 50% of the oxygen in the body, to make possible continued muscular activity in spite of widespread peripheral vasoconstriction and a reflex bradycardia. The muscle tissue is also capable of functioning anaerobically and accumulating a large oxygen debt without tissue damage. The brain has a higher tolerance to carbon dioxide and is less sensitive to its signal to initiate breathing. A series of muscular sphincters in the bronchioles permits a low air pressure in the alveolus even while diving to great depths, and thus a low partial pressure of nitrogen exists. This prevents adequate amounts of nitrogen to be dissolved in the blood to result in the bends. All this has been done for the dolphin while man has been adapted for an existence on dry land. Thus what is natural for the dolphin, we must supplement our bodies with machinery to do. So the fascination remains with the beautiful, graceful, diving dolphin .....

* * * * * * * *

PREGNANT DIVER UPDATE continued from page 87

What about the deliveries? What about the babies? These are the questions we all ask. All the babies were “normal” according to their mothers. Only one baby was under weight, at birth. The male babies outnumbered the females 61% to 39%. The complications that occurred during pregnancy included one premature birth, one septic abortion, and two miscarriages. (One of the women had two miscarriages before learning to dive and two more since diving). The normal rate of spontaneous abortions is 20%, for the general public, the rate among the respondees was less than 3%. There were seven Caesarean sections (12%). This procedure is becoming increasingly popular and the average rate is between 10-15% for the general public. All but one woman continued to dive after delivery.

From this survey, it seems that many women discontinued diving as soon as pregnancy was established, and the reason given was the lack of information on the safety or danger to the foetes. However, most women dived at least during the first trimester, at a time when the foetus is very vulnerable. Those who continued to dive as long as possible did not run into any apparent problems. Even the women who made deep dives reported no mishaps. I believe in good prenatal care and I recommend that pregnant divers limit their maximum depth to 33 feet, take it easy (make the easy dives), avoid overextending oneself, and use common sense.

CAN IT HAPPEN TO YOU?
Ron Pavelka (NAUI 4860, California)

What do you do when you follow the rules and still end up “paying the price?” Well it happened to me and it could happen to you.

If you are 21 years old, in good physical condition and have been diving for about 7 years, you might think that you have scuba diving under control. Your greatest vices are smoking half a pack of cigarettes per day and having a couple of social drinks before dinner. Since you are an avid diver and an active NAUI instructor who teaches the tables in every class, you feel you understand decompression sickness and how to prevent it. With all these things in mind, the forthcoming day of diving promises to be another fun day.

A Sunday in December 1977, dawns a little foggy, but after a beautiful, uneventful trip to Catalina we find ourselves in warm sunlight anchored in crystal clear waters. Our first dive is to be on The Valient, resting in her watery grave 90 feet below the surface. Since you are the instructor in charge of the advanced class on board, the boat skipper asks you if you would descend to the wreck site and survey the conditions prior to the group making its dive. The group was instructed to terminate their dive after 15 minutes of bottom time or when their air supply reached 800 psi (whichever came first). All of the students and their divemasters followed these guidelines. Here is where the story begins.

The following profile led to one of the most amazing experiences of my life. Read the following and try to determine what went wrong.

10.15 am	65 ft	BT 2 minutes. SI 7 minutes.
10.25 am	90 ft	Dive with group, surveyed wreck. BT 25 minutes. Made a decompression stop at 10 feet for 3 minutes. SI 9 minutes.
11.04 am	90 ft	Last person gets out of the water (one of the dive masters) and asks for assistance to recover anchor. Made a decompression stop at 10 feet for 3 minutes. BT 3 minutes. SI 2 hours

Approximately 10 minutes after surfacing from my second decompression stop I began to feel pain in my left elbow. Although the rest of my body felt fine. I became concerned. Many thoughts passed through my mind, but I knew “it couldn’t happen to me”.

Next we dived the Blue Caverns, I was under water at about 50 feet when I picked up a headache. Bottom time for that dive was 15 minutes. Back on board the boat I used pure oxygen for about 5 minutes. The headache went away but my arm continued to bother me.

We left the island around 4.30 pm and began our trip home. As it is at the end of most diving trips each diver had to tell his fish story of the day over a can of beer or a card table, to his follow divers. The pain in my arm persisted, but did not worsen until the following morning when I began experiencing extreme discomfort. The pains were deep inside my elbow and my hand (the last two fingers) became numb and unresponsive. After deciding, “it happened to me!” I was transported to the nearest chamber by a friend and was in the chamber about 15 minutes after my arrival to the hospital. I made two (2) recompression runs in a one man hyperbaric chamber, the second run was 12 hours after my first run. Each run was 3 hours in duration and I was breathing pure oxygen.

Unfortunately, I have residual effects left by the formation of N2 bubbles in the nerves in my elbow. Even now after two recompression runs I still experience a 30% loss of strength in my hand and find myself getting sore elbows and hands after strenuous exercising.

According to the tables I shouldn't have been bent, but are the tables failsafe within themselves or are there other factors that should be taken into consideration?

Read the following overall profile and answer that question. The week previous to the dive was no less hectic than any other week at the diveshop I manage. Up early every morning (6.30 am or so) and into bed late every night (1.00 am or so). My diving activity had been nothing more than usual the previous two weeks with seven open water scuba dives, with none greater than 50 feet. Thursday night before the dive I had a pool session with my basic class I was teaching and Saturday we went scuba diving at 25 feet for 30 minutes with the same class, this dive was terminated at 10.00 am.

That same evening I had a social evening in Hollywood, I consumed three drinks (the last at midnight) and got to sleep at 2.00 am. The alarm rang at 5.15 am and I awakened to prepare for the Catalina dive. I was able to sleep about 2 hours on the way over to our destination.

Everyone is aware that the physical condition of a diver plays an important role in how easily one can acquire decompression sickness. But how many people really pay close attention to how tired or rundown they are, especially when they're excited about an upcoming dive.

I've shared this episode with you in the hopes that you as divers, will pay closer attention to your physical and mental condition prior to a dive, and not become bent as I did. A night in the hospital and two runs in a hyperbaric chamber are not all that fun, and unfortunately a hyperbaric chamber only removes the bubbles, but cannot make up for the permanent nerve or tissue damage caused by decompression sickness. I was lucky! You should never incur decompression sickness if you evaluate yourself before each and every dive and allow yourself a substantial margin of safety.

(This paper is reprinted from *NAUI News* August 1978 by kind permission of NAUI.)

* * * * * * * *

SEA FRONTIERS

In 1954, the first number of the magazine, 32 pages illustrated in black and white only, was published under the title *Bulletin of the International Oceanographic Foundation*. In the following year, two numbers of 64 pages each appeared under the present title *Sea Frontiers*. By 1967, six numbers were being issued every year. Finally, in 1970, full-colour illustrations marked a great step forward, as increased membership made improvement possible. A feature that has continued since 1961 has been the series of coloured photographs of lighthouses on the back cover, forming a series that now numbers over 100 and which members have suggested should be assembled into a special publication.

During its history, Sea Frontiers, although appearing bimonthly only, has frequently scooped the daily newspapers with unusual information as, for instance, the discovery that land animals, under very special conditions, are able to breathe water instead of air for long periods and recover completely.