lasting. Deaths from pulmonary fibrosis have occurred after anaesthesia, where increased partial pressures of oxygen are normally used. Anaesthetists know that patients who have had Bleomycin should never be exposed to more than 0.3 ATA of oxygen, and preferably less.

Why should diving doctors worry about Bleomycin? Bleomycin is often used for the treatment of testicular teratomas. These tumours occur in the age group who dive and after successful treatment the diver may wish to return to diving. If he does he will be at risk of developing pulmonary fibrosis if he breathes an oxygen partial pressure of more than 0.3 ATA. Using compressed air, 0.3 ATA partial pressure of oxygen is reached at a depth of just over 4 m!

Obviously anyone who dives should give up diving after treatment with Bleomycin. It is an indictment of our compartmentalised thinking that I, an anaesthetist who has known for years of the danger of giving higher than normal partial pressures of oxygen to people who have had Bleomycin, never moved this information sideways into my diving medicine memory banks. I am grateful to Drs Hamilton, Williams and Wilmshurst for pointing out the relationship to diving.

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ANONYMOUS REPORTING OF DIVING INCIDENTS: A PILOT STUDY

Chris Acott, Allan Sutherland and John Williamson

Abstract

Current recreational diving safety practices in Australia and New Zealand leave much room for improvement. Incidents with the potential to reduce safety in diving are constantly occurring, and the vast majority result in no harm to anyone. Based upon techniques in current and successful use in civil aviation and anaesthesia practice, we suggest that the recreational diving industry should adopt an on-going, bi-national, Diving Incident Monitoring Study (DIMS), with the aim of improving sport diving safety and training standards. The proposed study could usefully supplement the existing morbidity and mortality data collection that is the present province of "Project Stickybeak". The results of such an incident study, conducted during the 1988 Annual Scientific Meeting of SPUMS, at Mana Island in Fiji, are presented and illustrate the power of this voluntary incident reporting technique for the objective identification of recurring human errors in sport diving practice. Analysis of the 65 reported incidents revealed unsatisfactory diving safety standards among medically qualified divers who might be considered to be safety leaders in the sport! Fifty-five per cent of the potentially harmful incidents occurred during the dive itself, but a quarter occurred during preparation for the diving. An important advantage of the incident analysis technique is its ability to suggest corrective strategies (specific improvements in training, practice, supervision and equipment design), which are directed effectively against the most commonly occurring and recurring hazards and errors among sport divers in Australia and New Zealand.

Introduction

Unsatisfactory safety standards in the practice and supervision of recreational scuba diving in Australia, and other countries, are shown by the steadily increasing clinical work load of Hyperbaric Medical Units[1], by regular medical publications[2,3], and also by a plethora of popular press reports, albeit some of the latter are sensationalised and ill-informed. Any considered effort to improve this state of affairs warrants attention and trial. A method is presented of incident reporting and analysis the efficacy of which for safety improvement has been established in civil aviation[4] worldwide, and which is directly applicable to sport scuba diving. The same technique is also currently being applied, with exciting early promise in human medicine, to improving the safety of anaesthesia[3,4].

Such constantly recurring errors during the supervision and practice of anaesthesia lie at the heart of most (at least 80%5,6) of the accidents that happen. The same is probably true of recreational diving and the analysis of such errors enables the recognition of the more common patterns, e.g. inadequate buoyancy control, and the development of *effective* corrective strategies, e.g. improvements in the design of buoyancy control devices (BCD) and weight belts, and in the training for, and practice with their use during diving.

The reporting and analysis of scuba diving "incidents" is quite simply a method of analysis of human error! Divers, just like the rest of the human race, err constantly and naturally, despite their repeated attempts (again just like the rest of the human race) to deny the fact! As a British aviation psychologist has so eloquently put it[7] ".. all human beings, without any exception whatever, make errors and .... such errors are a completely normal and necessary part of human cognitive function."

The interesting aspect of this aproach to safety improvement is that it is all “old hat”. This error analysis technique, originally called the Critical Incident Technique, was invented by Flanagan in the 1940s for application to United States military aviation[8] and even then he was acting upon a suggestion from Britain in the 19th century[8]. As a technique for safety improvement it works, but it will depend for its success in the diving upon the *voluntary* participation of all recreational divers and instructors.

An initial pilot study of such diving incident reporting was conducted by us at the recent Annual Scientific Meeting (ASM) of SPUMS at Mana Island in Fiji. About 50 divers (most with medical qualifications) dived from small boats, once or twice a day, over a period of 6 days. Fourteen of these divers voluntarily reported a total of 69 incidents.

Methods

The proposed study was introduced to those attending the ASM at an informal meeting. Emphasis was placed upon the potential value for such reports to improve diving safety, with the consequent benefits to everybody in diving, including the reporter him(her)self. The totally anonymous nature of the reporting was also carefully emphasised, and a prepared statement was circulated. This is reproduced as Figure 1 below.

As with the introduction of the incident concept in other such studies6,[8], it was necessary to present a definition of just what a “diving incident” was. This definition is given in Figure 2. The intention by the authors to publish the anonymous results of this pilot study, in the SPUMS Journal, was also declared. Although the study was conducted using the reporter’s own words, an existing written incident questionnaire, already in use by anaesthetists in Australia and New Zealand6, served as an illustration. This questionnaire formed the basis for a specific diving incident report form (Figure 3, page17), which we have designed for future preliminary trial among recreational divers.

The 69 incidents that were reported anonymously in writing were collected by us over the weeks following the Mana Island ASM. These were subjected to detailed analysis along the now well established lines developed by the pre-existing aviation and anaesthesia critical incident protocols5,6,[9,10].

FIGURE 1

DIVING INCIDENT MONITORING STUDY

This is a prospective, long-term study which asks recreational scuba divers to record, in an anonymous fashion, untoward incidents that occur to them or their companions, during diving activities. The study is an attempt to investigate the factors which predispose recreational divers to err. It is focused on the process of error, r*egardless of the final outcome of that error* (most incidents cause no harm to anyone). The study has no interest in culpability or criticism of individual divers. The study is anonymous and totally impartial, and we invite all scuba divers of all levels of experience to participate.

Filling out the brief questionnaire may at times prove tiresome, but we urge you to do it as soon as practicable following the dive. If you participate you will assist in improving the safety of diving for everyone, and you may well learn something about yourself. Thank you.

This study will form part of, and indeed is an extension of, the data that already exists in Australia and New Zealand for the study of diving safety known as “Project Stickybeak”.

FIGURE 2

DEFINITION OF A DIVING INCIDENT

1. An error by a diver, or a failure of his or her equipment to function properly.
2. The error or failure could have led to more serious consequences, had it not been detected or corrected in time.
3. It was an error by yourself, or one which you witnessed di*rectly.*
4. It occurred during the dive, or associated preparation and/or exit and recovery time.
5. It was clearly preventable or avoidable.

Results

Fourteen divers reported 69 incidents. These are detailed in Figure 4 on page17.

Associated Negative Factors[5]

(i.e. factors considered by some of the respective reporters as predisposing to the occurrence of their incident.)

1. Strong current
2. Inadequate safety line facilities (i.e. absent, too short)
3. Poor equipment maintenance
4. Absence of learned or written check protocols (e.g. gear check list, lost contact drill)
5. Too much equipment carried during the dive
6. Lack of familiarity with the dive site by dive leaders
7. Failure by dive leaders to match the dive site to the experience levels of divers present
8. Concealment by individual divers of inexperience with conditions at the dive site (e.g. ocean swell, boat diving)

FIGURE 3

SCUBA DIVING INCIDENT REPORT FORM (Mark 1)

1. Describe in your own words the incident you wish to report.

2. Whose incident/error was it?
Yours? Your buddy's? Someone else's?

3. When was it detected?
Preparation? Entry? Descent?
During Dive? Ascent? Exit?
Following entry?

4. Who first detected it?
You? Your buddy? Someone else**?**
Who? ———————— (no names)

5. What action was taken to deal with the problem?

6. Who took this action? (no names)

7. What influence did it have upon:-
a the dive plan?

b your state of mind?

8. Did any harm result? Yes No
Specify (optional):

9. What in your opinion was the basic cause of this incident?

10. What factors do you recognise as contributing to the occurrence of this incident?
(e.g. inexperience, unfit, etc.)

11. How many dives have you performed in your diving career to date?

12. Did your diving training:-
a) make you aware of the potential for this incident to happen? Yes No
b teach you to deal with it? Yes No

13. Have you a suggestion as to how such an incident may be prevented from recurring, either in your hands, or any other diver's?

14. Any additional relevant comments?

FIGURE 4

INCIDENTS REPORTED

DURING PREPARATION	**15**
Forgotten gear	4
Unsafe practice	4
Faulty assembly	3
Gear breakage	2
Lost items	1
Free-flowing regulator	1
ENTRY	**5**
Air not turned on	3
Gear misplaced	1
Gear dislodged	1
DESCENT	**7**
Underweighting	4
Equalisation failure	2
Snorkel in mouth	1
THE DIVE	**36**
Equipment misuse/misassembly	6
Equipment fault	4
(Maximum Depth Indicator faults = 3)	
Lost buddy contact	4
Lost diver (temporarily)	4
Out of air	3
Equipment dropped	3
Buoyancy control loss	3
Coral abrasions	3
Overweighting	2
Vision intereference (mask)	2
Unsafe practice (tables)	2
ASCENT	**4**
No reference point	4
(boat, Jesus/shot lines unseen)	
EXIT	**2**
Dropped Weight	1
Inadequate buoyancy control	1
TOTAL INCIDENTS	**69**

Associated Positive Factors[6]

(i.e. factors considered to contribute to the earlier detection and correction of some incidents.)

1. Carrying spare equipment
2. Carrying emergency safety gear
3. Carrying written gear check lists
4. Experience and patience

Discussion

ANALYSIS OF THE PILOT STUDY RESULTS

Equipment problems predominated in this relatively small series of diving incidents, either absence, misassembly, misuse, failure, or excessive amounts of it. Maximum depth indicator failures stood out. More emphasis on pre-dive checking and calibrating of these devices should occur. Failure to connect the scuba-feed to the buoyancy compensator during preparation was also notable. This is an omission which threatens buoyancy control and the success of any rescue techniques! Diving is an equipment orientated sport, and it seems necessary to keep emphasising that good maintenance and regular familiarisation with one's own, and one's buddy's equipment, is fundamental for safe diving.

Buoyancy problems were prominent, and are always a threat to divers' safety. Allied to this, familiarity with, and the ability to test for, correct weighting were clearly lacking among some. Uncontrolled or unplanned alterations in depth carry most serious potential consequences[2].

It is distressing that absence or failure of air supply also feature in these reports. It is clearly not a rare event in recreational diving, despite the emphasis given in most reputable training programmes to turning on the cylinder before entering the water and to checking one's contents gauge regularly. Further research into these dangerous habits among recreational divers is warranted.

It is also embarrassing to report the high incidence of clearly unsafe practices among this so-called informed group of recreational divers! Loss of buddy contact, ascent beyond the reach of the "Jesus line", perching on the edge of the dive boat at sea with weight belt on, but no buoyancy device, diving beyond so called "no-decompression-limits", or without a timing device, or when not completely well, are all invitations to trouble. A prominent Australian diving medical physician was startled to see one of his dive party happily self-administering several puffs of salbutamol prior to entry! Lost contact drill is tending to become a forgotten protocol. All dive leaders must formally rehearse this protocol with all divers, prior to commencement of divng.

Despite the accepted medical importance of "slow, careful ascents" in the prevention of both decompression sickness and cerebral arterial gas embolism, here we had some divers ascending in open, and sometimes rough water, without even visual reference! The reporters of such incidents felt that the dive organisation predisposed to thse events by the inadequate provision of shot lines. Once again it is necessary to emphasis that one has to plan the EXIT, before one BEGINS the dive. It is not good enough to start thinking about the exist after one is in the water.

Happily, no one was underneath the diver who dropped his weight belt during exit!

The majority of reported incidents in this study (55%) occurred during the dive. the next most hazardous period for incidents was during preparation. Interestingly, this is similar to incident occurrence patterns in anaesthesia5,6.

On a positive note, the study also bears out the results of other such studies of human performance[6,8,9], by showing the value of experience, and check lists, for safety.

THE REPORTING OF DIVING INCIDENTS

It is important to appreciate that most diving incidents cause no actual harm to anyone. They occur repeatedly because all humans err repeatedly, but most are recognised and corrected before they progress to the accident stage (e.g. entry with an uninflated BCD, which is rapidly inflated by scuba-feed without fuss, provided the scuba-feed is connected!!). However, the written reporting of such incidents (which have until now been passing unnoticed and "unused") is a most important contribution to the build-up of a body of data which forms a powerful means of developing corrective strategies[9] (see below), for the improvement of diving safety for everyone.

Such incident reporting, being entirely voluntary, can never reveal the *absolute* incidence of any error among divers. This would require that every single incident that occurs be reported, an unrealistic expectation of human behaviour! However the data, provided enough divers participate in returning completed reports (Figure 4), will tell the *relative* incidence of errors and incidents. This will enable the most effort to be logically directed towards the most common and/or the most potentially dangerous recurring incidents in sport diving practice. The data is also reasonably objective (Figure 2), and is thus difficult for the irresponsible diver, or dive charter operator, or the ignorant bureaucrat, to refute once it is published.

An important consideration for those considering participating in such a Diving Incident Monitoring Study (DIMS), is the assurance of confidentiality, as well as anonymity, of the data supplied. This is ensured both by the totally anonymous design of the questionnaire (Figure 4), and the built-in security of the central data-collation bank, which would be a specially designed computer programme, operated and accessed by only one or two trustworthy members of the South Pacific Underwater Medicine Society. The blank forms could be made widely available at all recreational diving outlets across the two nations. Posting by divers of their completed questionnaires could be either direct to a central SPUMS data facility (hopefully post free), and/or by handing to the senior, and trusted, dive supervisor at the end of a diving trip. The latter would then despatch the completed forms to the central SPUMS facility. Such a supervisor would also be available for advice concerning the filling in of any such report form.

It is planned that the important feed-back of the Australasian data, once enough has been collected to make it meaningful, will occur on a regular, perhaps annual, basis in the pages of the SPUMS Journal, and will be available to the principal sport diver training facilities in Australia and New Zealand.

Conclusions

Corrective strategies suggested by the anonymous reporting of diving incidents pilot study conducted at Mana Island in 1988:-

1 Carry a gear check list in your dive bag
2 Ensure regular, at least annual, gear maintenance
3 Practice regularly with one's own gear in the pool. Buoyancy control takes in-water practice. Consider the use of safety straps on extra gear (e.g. camera)
4. Routine with a new buddy:-
 4.1 Discuss and agree upon underwater signals and lost contact drill to be used.
 4.2 Inspect and test your buddy's gear, especially inflation, releases, and safety items.
 4.3 "Plan your dive, and dive your plan".

It is also suggested that the adoption of an on-going Diving Incident Monitoring Study (DIMS) may be a fruitful approach to the improvement of the inadequate existing safety standards among recreational divers.

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DIVEDATA DATABANK INTERNATIONAL UPDATE

Douglas Walker

The proposal to set up a databank to service reports concerning all types and severities of diving-related problems has been raised for discussion in these pages previously.[1] There are two major questions which must be answered in connection with any project such as this. The first is, is the objective worth achieving? The second is, is the plan practical ? There is clear evidence for answering "Yes" to both questions.

To justify the need for such a project requires no more than to refer to the history of diving medicine, which developed slowly as reports were published about the problems affecting caisson workers and divers. None of the problems had been predicted. Though the information came from caisson workers, divers, employers, engineers and physicians it was the analysis of the information by physiologists and physicians which pointed out the probable causes and the necessary actions to reduce risks. Nowadays it is so difficult to obtain information concerning military or commercial diving accidents that it is obvious that self-regulation by interested parties does not work for the general benefit of the diving community. Of course medical opin-