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OUT-OF-AIR ASCENTS FROM THE DIVING INCIDENT MONITORING STUDY

Chris Acott

Introduction

This paper presents the Diving Incident Monitoring Study data available up until the end of 1992 on the out-of-air/low air problems. It is an analysis the safety of the various emergency procedures designed to cope with this situation. These emergency procedures can be placed in one of three groups.

1 An ascent to the surface, exhaling all the way. Some call this a free ascent. In this paper it is called a non-breathing ascent. This technique includes an emergency swimming ascent.[1,2]

2 The sharing of a buddy's regulator, either a spare second stage (octopus breathing) or the buddy's second stage (buddy breathing).[1,2]

3. The use of a totally separate air supply from a spare cylinder (i.e. a pony bottle or SPARE AIR).[1,2] None of the ascents considered here was in this group.

An out-of-air situation is not an uncommon event in diving. 82 (15%) of the 533 incidents reported have involved an out of air problem. 21 (26%) of these incidents involved morbidity (Table l) and this represented 8% of all the harmful incidents reported.

There were 49 low air incidents, and 19 (40%) of these became an out-of-air problem. Of the remaining 30 low air incidents 9 (33%) resulted in harm, (seven incidents of decompression sickness, one of cerebral arterial gas embolism and one of salt water aspiration). These harmful low air incidents were associated with omission of decompression stops, poor dive planning, poor air maintenance and various problems developing at a "Safety Stop" resulting in a rapid ascent to the surface.[3] The addition of another incident (ie the loss of a fin or the retrieval of an anchor at the end of a dive) were the main causes of a low air problem becoming an out-of-air situation.

TABLE 1

HARMFUL INCIDENTS FOLLOWING OUT-OF-AIR ASCENTS

Sequelae	Incidents
Decompression sickness	9
Cerebral arterial gas embolism (CAGE)	3
Pulmonary barotrauma and CAGE	1
Pulmonary barotrauma	2
Salt water aspiration	4
Salt water aspiration and complications	1
Near drowning	1
Total	**21**

Experience

An out-of-air problem is not confined to the inexperienced as 71% of the divers running out of air had better than basic qualifications (Table 2). However novice divers have a greater chance of injury. Students, basic and open water divers accounted for all the incidents of cerebral arterial gas embolism, pulmonary barotrauma, salt water aspiration, near drowning and two incidents of decompression illness. There were 14 harmful incidents in 43 novices, an incidence of approximately 33% while the more experienced divers had 7 harmful incidents in 39 ascents (18%).

TABLE 2

QUALIFICATIONS

Certification	Number	%
Basic	18	22
Open Water	25	31
Advanced	12	15
Dive master	4	5
Dive instructor	11	13
Commercial	6	7
Not recorded	6	7
Total	**82**	**100**

Causes and contributing factors

Not all the incidents had a recorded cause. Table 3 lists the identified causes of the out-of-air problem while Table 4 lists the associated contributing factors and Table 5 the contributing factors in those coming to harm. Many incidents had more than one contributing factor. This was commoner in those incidents resulting in harm

TABLE 3

CAUSES OF OUT-OF-AIR SITUATION

Did not check contents gauge regularly	24
Inaccurate contents gauge	16
Unable to read contents gauge	2
Free flowing 2nd stage	5
Air not fully turned on	5
First stage problem	4
Air used frequently to maintain buoyancy	4
Ruptured air hose	3
Kinking air hose (Hookah)	2
Total	**65**

TABLE 4

CONTRIBUTING FACTORS

Error in judgement/incorrect decision	30%
Failure to check equipment	29%
Inexperience in diving	29%
Inattention	20%
Malfunction or failure of equipment	18%
Total	**126%**

Discussion

A calibrated contents gauge is essential for safe diving. Contents gauge inaccuracy featured in 20% of the out-of-air situations. This is a disturbing figure. Contents gauges are not often serviced once purchased. Regular calibration, once a year, should be done. Because a diver needs an air supply at all times underwater, it may be wise to have a back up system. A sonic reserve in the pillar valve of the cylinder has been proposed[4] as a warning of a low air situation. New computer technology will enable all air data to be displayed at the diver's wrist with the contents sensor part of the 1st stage. However, the diver still has to look at the gauge on his or her wrist!

TABLE 5

CONTRIBUTING FACTORS AND HARM

Error in judgement/incorrect decision	44%
Inexperience in diving	39%
Insufficient training	28%
Poor communication	22%
Failure to understand equipment	22%
Failure to check equipment	22%
Total	**177%**

Using the power inflator to maintain buoyancy appears to be a problem associated with experienced divers. Failing to check their contents gauges frequently enough affects both inexperienced and experienced divers. These two causes accounted for 34% of the out-of-air ascents.

Infrequent checking of the contents gauge and frequent activation. of the power inflator for buoyancy control indicates poor diving technique.

Problems associated with hookah diving can be simply solved by the use of a "bail out" bottle. However, these bail out bottles should be checked and serviced in the same manner as the regular supply.

Malfunction or failure of equipment was a result of a lack of suitable servicing and calibration.

Failure to check, failure to understand, errors in judgement and inattention are human errors and can be corrected by appropriate training, as can insufficient training.

Action taken

In the 82 incidents, in which all reached the surface, 40 shared an octopus regulator, 16 buddy breathed and 26 ascended without an air supply. Of these twenty six, 21 reported that an alternative air source (pony bottle etc.) would have helped the situation.

Controlled Ascent

Fifty (61%) of the out of air problems did not involve a rapid ascent to the surface. These resulted in 3 cases of salt water aspiration. Of these 50, 17 ascended to the surface without help with one diver aspirating salt water. Of the remaining thirty-three, 27 involved an ascent with an octopus and 6 buddy breathing. Two of these ascents resulted in salt water aspiration (one octopus breathing, and one buddy breathing). These results indicate that a controlled non-breathing ascent has a morbidity rate at least equal to that of an ascent using an octopus or buddy breathing, but more data are needed. Table 6 provides a summary.

TABLE 6

OUT-OF-AIR WITH A NORMAL ASCENT

Number	Method	Complications
17	Unaided ascent	1 SWA
27	Octopus breathing	1 SWA
6	Buddy breathing	1 SWA with complications
50	**Total**	**3**

Rapid Ascent

Of the remaining thirty-two who made a rapid ascent to the surface, 18 (56%) ascents resulted in harm (Table 7). A rapid ascent increases the morbidity from 6%. (3 out of 50) to 56% (18 out of 36).

A rapid ascent breathing from an octopus invoIved a 26% chance of causing harm, while a rapid buddy breathing ascent involved a 50% chance (Table. 8). All the rapid, uncontrolled non-breathing ascents (i.e. neither octopus nor buddy breathing) involved morbidity.

TABLE 7

OUT-OF-AIR WITH RAPID ASCENT

All ascents		**32**
Harmful		**18**
Decompression illness	9	
Cerebral arterial gas embolism	4	
Pulmonary barotrauma with CAGE	1	
Pulmonary barotrauma	2	
Salt water aspiration	1	
Near drowning	1	

TABLE 8

RAPID ASCENTS AND HARM

Octopus ascents		**13**
Harmful incidents		**3**
Cerebral arterial gas embolism	1	
Pulmonary barotrauma	1	
Salt water aspiration	1	
Buddy breathing ascents		**10**
Harmful incidents		**5**
Decompression illness	3	
Pulmonary barotrauma and CAGE	1	
Near drowning	1	
Non-breathing ascents		**9**
Harmful incidents		**10**
Decompression illness	6	
Cerebral arterial gas embolism	2	
Pulmonary barotrauma	1	
Saltwater aspiration*	1	

* This diver developed decompression illness later, so having two harmful incidents due to running out of air.

Conclusions

From these data, a non-breathing slow exhaling ascent is associated with the same or less morbidity as a slow, aided (octopus or buddy breathing) ascent. However, as the ascent rate increases, so does the morbidity rate. This is true for both non-breathing and aided ascents. However, a rapid ascent breathing from an octopus is associated with a much lower incidence of morbidity than a buddy breathing or non-breathing rapid ascent.

If a diver is able to control his or her ascent rate then the chances of morbidity are reduced. The ability not to panic and to think about the task involved are significant factors in decreasing harmful incidents. Therefore, from the limited data presented, controlled exhaling ascents should be an important part of diver training.

References.

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A TRAINING AGENCY PERSPECTIVE OF EMERGENCY ASCENT TRAINING

Drew Richardson and Terry Cummins

Emergency ascent training has been a controversial subject in recreational diving since the early 1970s.[1] The associated controversy revolved around techniques, psychological and physiological considerations and concern about the changing legal climate.

The Catch 22 is this: Is it wise and ethical to train divers in emergency ascent techniques, even though the training itself may provide some hazard, or to not train these procedures and have the lack of training itself provide the hazard? We would have a moral concern over any situation where a student would attempt a unsuccessful emergency ascent, having never been trained in the procedure. As diving educators, instructors must concern themselves with practical training so that students will dive safely without supervision after certification.

Diving accident statistics tell us that divers do indeed experience loss or interruption of air supply, despite our best instructional efforts, sometimes with less than satisfactory results.[2,3] For this reason, emergency ascent training has been included in every entry level scuba course since the inception of diving instruction. It was improved in the late 1970s and again in the early 1980s. Literally millions of safe ascents have been made by divers involved in training programs. More importantly there is no way for anyone to tell how many near misses occur or how often injury or death has been avoided by these techniques in the field.

15 years ago concerned persons got together to discuss emergency ascent training. They tried to develop a mutual understanding in order to improve the safety and training of divers. The proceedings from the 15th Undersea Medical Society Workshop on Emergency Ascent Training,[4] has been discussed in another paper in this issue[1] and that discussion will not be repeated here. These goals were achieved. It is an extremely positive sign that we are all gathered here today, for similar reasons, to continue this worthwhile process.

Despite misconceptions, sensationalism, and a lack of understanding in some quarters, indications support scuba diving as one of the safest sports.[1,2] From time to time, recreational scuba diving finds itself under scrutiny, because of the reckless habits of a few divers. Fortunately improper diving behaviour and poor decision making are not the norm for recreational scuba divers. By and large, divers and diving are becoming safer. This is largely due to significant improvements in the standards and training methodologies of the training organisations, as well as improvements in equipment technology.

What is the incidence of morbidity and mortality in emergency ascent training?

During open water training PADI requires three normal ascents and one buddy breathing ascent, one alternative air source assisted ascent and one controlled emergency swimmings ascent. The minimum number of emergency training ascents each individual performs (as required by standards for certification) is three. Table 1 shows the total number of PADI entry level certifications by year and the number of injuries and deaths for the period 1989-1992. It also shows the minimum number of

TABLE 1

MORBIDITY AND MORTALITY REPORTED DURING PADI EMERGENCY ASCENT TRAINING 1989-1992

Year	Entry level trainees	Emergency ascents	Injuries reported	Deaths
1989	276,065	828,195	8	-
1990	304,352	913,056	8	-
1991	319,708	959,124	7	2
1992	351,443	1,054,329	10	-
Total	**1,251,568**	**3,754,704**	**33**	**2**