Unfortunately no details of this case are provided.

Sudden loss of consciousness is a problem where the presence of a buddy is essential for survival. There were five such incidents, two being the result of air embolism, one followed drum perforation at 7m, and the fourth was the climax of events when an apprehensive novice had buoyancy problems while underwater, then "beat the demand valve" (regulator) at the surface and inhaled water. The remaining case occurred in an under-ice dive by a novice and two certificated divers. The novice's weight belt slipped to around his knees, then he ran out of air and snatched the regulator of the nearest buddy, who had to buddy breathe unexpectedly with the third diver. Luckily they broke through the overlying ice as sharing started to become chaotic. The novice was unconscious and had purple lips when he got to the surface, but breathing restarted when his neck was extended. Only training prevented an incautious dive from ending in tragedy.

The members of the Diving Incident Panel deserve more than a vote of thanks. They deserve better Incident reports from divers.

SCUBA ACCIDENTS ON THE MONTEREY PENINSULA AND EXPERIENCE WITH A SINGLE LOCK CHAMBER 1971 - 1981

Takashi Hattori

The primary purpose of a single lock 7ATA chamber is for the transport of diving victims under pressure to a more sophisticated double lock chamber. However, circumstances have caused such chambers with oxygen capability to be used for definitive treatment of the less serious and less complicated cases of decompression sickness (DCS) and arterial gas embolism (AGE). Such a situation has existed on the Monterey Peninsula for the past ten years.

BACKGROUND

This is a review of the scuba diving accidents from 1971 to 1981 and their causes as well as the result of their treatment. Some background information is provided to give an overall picture.

The California Parks and Recreation Department estimates that about 50,000 divers visit the Monterey Peninsula yearly. A conservative estimate is that one-half of these divers are students in diving classes for open water training.

70 per cent of all ocean diving classes held north of San Luis Obispo are held on the Monterey Peninsula. This would include the northern two-thirds of California.

The chamber is located at the Pacific Grove firehouse, and operated by the Pacific Grove Marine Rescue Patrol of which the author is a member.

The author was involved in the treatment, investigation and reporting of almost every case recorded as well as being present for most of the autopsies, which are required for all coroner's cases in California.

ACCIDENTS

The accidents were separated into five categories:

1. In trouble; those who found themselves in a dangerous situation from which they were able to extricate themselves with or without outside help.
2. Near Drowned.
3. Drowned.
4. Decompression Sickness (DCS).
5. Arterial gas embolism (AGE).

TABLE I

DIVING ACCIDENTS ON THE MONTEREY PENINSULA 1971 - 1981

		Subtotal
In Trouble	45	45
Near Drowned	31	
		68
Drowned	37	
DCS (Divers)	18	18
(Flyers)	6	
Arterial Gas Embolism	21	21
		152

Total number of divers on peninsula = 500,000
Total number of divers in classes = 250,000

Table I shows that most of the fatal accidents during scuba diving end up as a drowning. This is in agreement with the University of Rhode Island study. There were 37 drownings and 6 fatal cases of AGE. There were no deaths from DCS.

In trouble, near drowned and drowned

Heavy surf contributed to more accidents and fatalities than any other single cause. Most of these were due to entering the surf against one's better judgement, but a few were victims of the rapidly changing conditions for which Monastery Beach is notorious.

Unknown. Most were divers who failed to surface after a dive and whose bodies were recovered hours to days later. Autopsy usually was not too helpful due to the deteriorated condition of the body.

Deep dive. Of the eight divers known to me who have gone deeper than 150 feet, five are dead. I am aware that many more have gone to this depth and beyond and returned safely, but the percentages are certainly not good.

TABLE II

IN TROUBLE,
NEAR DROWNED AND DROWNED DIVERS

Cause	In Trouble	Near Drowned	Drowned
Heavy Surf	31	7	12
Unknown	0	2	12
Deep dive	0	0	5
Kelp	1	4	2
Exhaustion	2	2	1
Air embolism	0	3	1
Cardiac	3	0	1
Medication	1	1	1
Equipment Failure	0	1	0
Hypothermia	0	2	0
Buddy Breathing	0	1	0
Out of Air *	1	3	1
Hyperventilation	1	0	0
Hypoglycaemia	1	0	0
Miscellaneous	4	6	1

* (4 AGE)

Kelp. Entanglement in the kelp peculiar to the west coast has led to a significant number of accidents including death by drowning.

Out of air. Here is an interesting breakdown of what the end results were in eight cases:

air embolism	3
near drowning	3
AGE and drowned	1
in trouble	1

Of the other contributing causes of accidents, almost all have been mentioned at one time or another by the late Dr Charlie Brown in his many articles in magazines and journals on diving medicine.

The survival figures of the drowning accidents approximate those reported by Dr Modell of 91 cases over a ten year period in CHEST in 1976.

All who were awake on admission to the emergency room (ER) survived.

All who arrived with spontaneous respiration and heart beat survived.

None admitted having cardiopulmonary resuscitation (CPR) and with fixed dilated pupils survived.

None survived whose arterial pH was 6.8 or lower, or whose PaO_2 was below 40 mmHg.

Two survived with mild to moderate brain damage.

Two are still comatose two and four years after the accident.

PEEP was used in all cases requiring endotracheal intubation.

Decompression sickness

There were no deaths from decompression sickness. I am curious as to why we had so many peripheral nerve cases in comparison to Type I and other Type II cases.

TABLE III
DECOMPRESSION SICKNESS

TYPE	DIVERS	FLYERS
Type I (pain only)	4	3
Type II	4	3
Type I & II (mixed)	10	
Peripheral nerve	5	
Spinal cord	2	
Staggers	1	
Chokes	1	
Cerebellar	1	

Statistics include both divers and flyers. Table 5 was the most often used US Navy Table (14 of 25 cases) with one recurrence left with some permanent residual signs. This diver initially developed weakness of both lower extremities on surfacing from an uneventful dive. He had to be assisted into the boat, but by the time he was brought ashore and to the firehouse, he was asymptomatic except for a slight paraesthesia of the legs. Paraesthesia cleared within ten minutes at 60 feet on oxygen so the treatment was completed on US Navy Table 5. About two hours later he developed paraplegia while in the hospital. He was transported to the San Diego double lock chamber in our portable chamber for further treatment. One case of staggers was treated with oxygen at 35 feet for two hours on Dr Behnke's advice. He was cured with no residual. This was before we started using oxygen by mask, so we had to flood the entire chamber with oxygen.

One case of cerebellar involvement with ataxia cleared completely during transport to Monterey. "He received 500 ml of dextran and 20 mg Decadron IV and oxygen by mask en route. He was observed overnight in the hospital and discharged the following day asymptomatic. In the 20th UMS workshop on the treatment of serious DES and AGE, Dr Fructus reviewed 67 cases of DCS who had to be transported over long distances to the chamber. During transport some received no supportive treatment, some received oxygen by mask, others received Dextran, Cortisone or aspirin IV. Those who received no supportive treatment during transport showed no change in their condition, but among those who did receive such treatment, a surprisingly large number improved or became asymptomatic.

TABLE IV
DECOMPRESSION SICKNESS
TREATMENT PAIN ONLY TYPE I

Table used	Number of cases	Cleared after first treatment	Recurred, cleared with repeat treatment
5	5	4	1
6	1	1	0
1A	1	1	0
TOTAL	7	6	1

TABLE V
DECOMPRESSION SICKNESS TREATMENT
TYPE II AND TYPE I & II

Table used	Number of cases	Cleared with one treatment	Cleared with more than one treatment	Permanent residual symptoms
No * recompression	1	-	-	
5	9	6	2	1
6	5	4	1	0
6A	2	1	1	0
O2 at 35 feet for 2 hours	1	1	0	0
TOTAL	18	12	4	1

* cleared during transport on oxygen, plus IV steroids and dextran

TABLE VI
DECOMPRESSION SICKNESS
TIME FROM ONSET TO TREATMENT

Time in hours	Number of cases	Cleared with one treatment	Better or improved or cleared with repeated treatment	Permanent residual symptoms
Less than 1	5	4	0	1
1 - 2	4	3	1	0
2 - 4	3	3	0	0
4 - 6	3	2	1	0
6 - 24	4	3	0	1
24	5	3	2	0
* No recompression	1	-	-	-
TOTAL	25	18	4	2

* Cleared during transport on oxygen, plus IV steroids and dextran.

Fifteen of 25 cases were treated within six hours of developing signs or symptoms of DCS. Most of those treated with more than six hours delay were divers who had gone home before calling for help or had hoped that whatever was bothering them would go away.

Arterial Gas Embolism

Table VII shows that only 4 of the 21 cases of AGE developed any sort of haemoptysis. Older texts emphasised this finding. Perhaps the small number of cases in my series was unrepresentative.

Before we added oxygen capability, we did treat one case of rapidly improving hemiplegia on US Navy Table IA. Only one death occurred in the chamber. This diver died while our chamber was being passed into a double lock chamber in San Diego. Death was due to a combination of air embolism and drowning. All six fatal cases were found unconscious or were unconscious on admission to the ER having CPR. About one-third of the cases showed neurological involvement other than unconsciousness. Due to the proximity of the chamber, 7 of 14 cases that were recompressed were treated within one hour of the accident, and an additional four cases within two hours. Two cases cleared without recompression.

TABLE VII
ARTERIAL GAS EMBOLISM

Unconscious	(3 haemoptysis) (6 fatal)	11
Stuporose	(1 haemoptysis)	3
Hemiplegia		1
Hyperactive reflexes		1
Ankle clonus		1
Vibration/vestibular		1
Hemiparesis		1
Haemoptysis, weakness		1
Pulmonary, renal		1
TOTAL		21

Pure panic was the biggest culprit leading to AGE. Also, three cases occurred even though the divers claimed they were letting air out during ascent (two

TABLE VIII
ARTERIAL GAS EMBOLISM TREATMENT

Table used	Number of cases	Cleared with one treatment	Cleared with repeated treatment	Died
1A	1	1	0	0
5A	1	1	0	0
6A	3	3	0	0
4	9	7	1	1
Cleared Spontaneously	2	-		
Dead on arrival	5	0	0	5
TOTAL	21	12	1	6

TABLE IX
ARTERIAL GAS EMBOLISM
TIME OF ONSET TO TREATMENT

Time	Number of cases	Cleared with one treatment	Cleared with repeated treatment	Died
1/2 hr	1	1	0	0
1/2 - 1 hr	6	6	0	0
1-2 hrs	4	2	1	1
2-3 hrs	1	1	1	0
3-6 hrs	2	2	0	0
Cleared without recompression	2	-	-	- * 5 Dead on Arrival
TOTAL	16	12	2	6*

of these were during free ascent training one-on-one facing their instructor). Although the second edition of Diving and Subaquatic Medicine is somewhat dubious of the so-called 'air trapping' in the lower lobes that might happen with the 'blow and go' type of ascent, I do not think it can be entirely discounted. It may be because I do not have any other explanation, though air trapping in bullae too small to be seen on X-ray could be a factor.

TABLE X
CAUSE OF ARTERIAL GAS EMBOLISM

Panic	8
Exhaling (free ascent)	3
? Breath hold	3
Unknown	3
Buddy breathing	2
Breathing	1
Pulled to surface	1
TOTAL	21

FIRST OCEAN DIVES

Non-fatal accidents

Among the 29 non-fatal cases, rough surf was the worst culprit, responsible for 13 accidents. Air embolism was next with six cases. The remainder were singular occurrences. The cases involving hypothermia, out of air, and exhaustion all involved students at the tail end of their particular class, being 'checked out' by the instructor, and in each case were in the water for about an hour. The out of air student was using rented equipment and did not know how to turn on the 'J' valve. The hypothermic student could not afford a wetsuit so he was snorkelling around for an hour in a surfer's suit. He had become so cold that the regulator fell out of his mouth and he started to drown and would have if his buddy had not pulled him to the surface. Rectal temperature was below the 90 degree calibration of our thermometer.

Fatal accidents

Three of the eight cases were due to air embolism. All three were due to panic (two were during free ascent training). Two drowned for cause unknown. The rest are self explanatory.

STATISTICS

For the most part, there are no comparable figures for those who got "into trouble", or the number of near drownings as compared with the drowned, or the number of accidents in each category due to running out of air, or from hypothermia, or rough surf, etc.

As for fatalities, the percentage of deaths due to AGE (14%) and first ocean dive (18%) are comparable to

TABLE XI

ACCIDENTS ON FIRST OCEAN DIVES

NON FATAL CASES	
Rough surf	13
Air embolism	6
Chokes	1
Out of air	1
Hypoglycaemia	1
Hypothermia	1
Exhaustion	1
Medication	1
Epilepsy	1
Ear squeeze	1
Laryngospasm	1
Near-drowning	1
TOTAL	29
FATAL CASES	
Air embolism	3
Cause unknown (drowned)	2
Cardiac	1
Medication	1
Rough surf	1
TOTAL	8

the University of Rhode Island (URI) statistics of 21% for AGE and 15% for first ocean dive. The percentage of drownings is much higher (85%) compared to URI (62%).

TABLE XII

RATIO OF ACCIDENTS: DIVERS

Based on 500,000 divers

Accident	152	1:3,300
In trouble	45	1:11,000
Near-drown	31	1:17,000
Drowned	37	1:14,000
Non-fatal	75	1:7,000
Fatal	43	1:12,000
DCS	18	1:28,000
AGE	21	1:24,000

First Ocean Dive (250,000 divers)

Non-fatal	29	1:8,400
Fatal	8	1:31,000
AGE	9	1:28,000
TOTAL	37	1:6,800

Drowning	34/43 = 85%
AGE	6/43 = 14%
First ocean dive	8/43 = 18%

Some surprising figures are that the incidence of AGE on first ocean dives is not that different from the overall incidence. It was 1:28,000 for the first ocean dive, and overall, 1:24,000.

The non-fatal accidents were also about the same, 1:8,500 for the first ocean dive and 1:7,000 overall.

The incidence of fatalities among the first ocean dive was almost one-third less than overall, 1:31,000 for the first ocean dive, and 1:12,000 overall.

CONCLUSIONS

Rough surf presented the greatest hazard to life and limb on the Monterey Peninsula.

Arterial gas embolism is a distinct hazard on the first ocean dive.

Signs and symptoms of AGE need to be revised as to their frequency of appearance as well as which are emphasised:

1. Haemoptysis, "coughing up blood". True haemoptysis results from bleeding within the lungs for whatever cause with subsequent "coughing up" of blood. Twelve years ago this was emphasized to the extent that I thought practically all cases of AGE had haemoptysis. This is not so, only one in five cases showed this in my series. One can also aspirate blood from a nose bleed or sinus squeeze, so these need to be kept in mind.

2. Loss of consciousness was the most common finding in AGE, but about one-third of my series showed neurological signs and symptoms other than unconsciousness.

3. Any neurological sign or symptom caused by AGE can occur with DCS, so history is all important. An unconscious patient cannot give a history. More than once I have been on the verge of recompressing a diver because I could not rule out AGE for the simple but all important reason that no-one who could give some kind of history of the diving accident accompanied the victim to the emergency room. One must always remember that if the physician cannot rule out the possibility of AGE or of DCS for lack of history, the victim will have to be recompressed!!

Panic for whatever cause resulted in a disproportionate number of AGEs.

Chances of survival are grave for those admitted to the ER unconscious with fixed dilated pupils and requiring CPR.

Instructors need to be conscious of the amount of time spent in the water by classes. Running out of air can result in a serious accident.

In spite of the hazard of AGE, I believe controlled emergency swimming ascent is a desirable part of open water training, BUT NOT ON THE FIRST OCEAN DIVE

This paper was presented at the November 1981 meeting of the North Pacific Chapter of the Undersea Medical Society.

PUBLICATIONS OF INTEREST

Diving Accident Management Manual

Dick Rutkowski (NOAA and Florida Underwater Council)

DAN Underwater Diving Accident Manual

G Yancy Mebane MD, Arthur P Dick MD)

NASDS Diving Log Book

These publications illustrate variations on the theme of presenting basic Diving Medicine information to those to whom a diver may apply for advice and management after a possible "diving problem". The first line of protection from inappropriate management will always be the awareness of the victim diver and his companions of the possible diagnosis and correct treatment and their persistence in putting this convincingly to persons without knowledge of Diving Medicine. This is a "selfish" reason for divers to understand and remember this portion of their training days. Unless divers recognise that they may be suffering from a "bend", "squeeze", air embolism, spinal bend, post-hyperventilation blackout, etc, there is very little chance that anyone else will diagnose their problem. Without early and correct diagnosis, treatment will be possibly critically inadequate.

The NOAA/Florida Underwater Council publication is in the nature of educational material to inform and alert doctors, etc, who are "at risk" of being presented with divers with problems. It has a management flow chart which includes both the local (Dade County Fire Rescue) and the national Diving Accident Network (DAN) contacts for advice and management. It also contains a report form to send with the patient. Some copies of this booklet have been kindly made available for supply to interested readers (please send $1.00 p&p).

The DAN booklet offers more detailed information on diving accidents, with concise advice on diagnosis and initial management. The Management Flow Chart is much simpler than that in the NOAA booklet, though similar in intent. Both these publications stress that there must be NO ATTEMPT AT IN-WATER RECOMPRESSION. The emergency phone number for DAN is clearly printed. The booklet