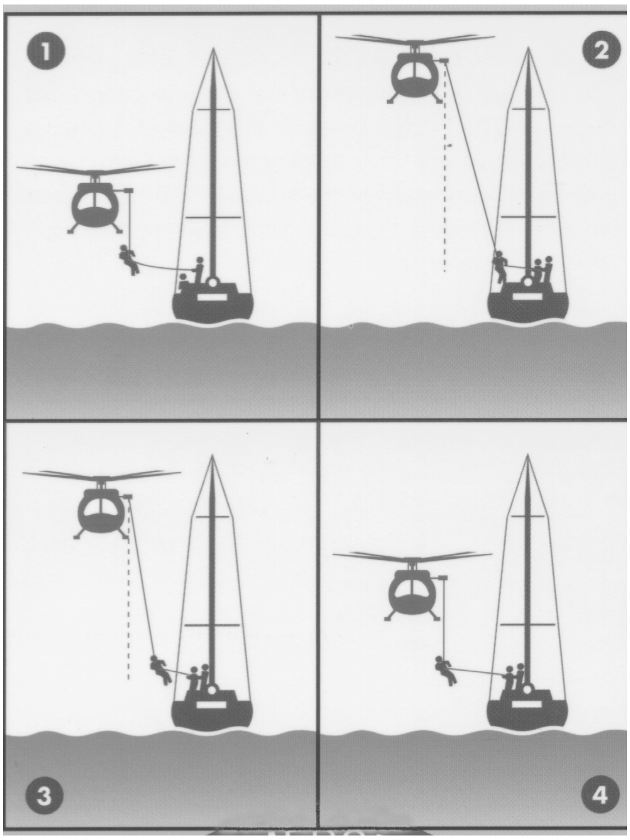
The weighted end of the line is lowered to the deck of the vessel. If available, two deck crew should receive this and take in the slack, coiling loose line onto the deck or better still, into a bucket clear of obstructions.

THE HI-LINE MUST NEVER BE ATTACHED TO ANY PART OF THE VESSEL !!!

Tension on the line should be maintained to keep the line taut. Do not heave-in the line at this time. Deck crews are advised to wear gloves whilst handling the Hi-line (Diagram 1)



Once the line has been taken by the deck crew, the helicopter will move away from the vessel to prepare the winchman for lowering to the deck. At this time the deck crew must pay out the Hi-line. After winching out the winchman, the helicopter will climb to a safe height over the masts and obstructions whilst lowering the winchman to keep him level with the transfer area. The deck crew should take up the slack in the Hi-line so that the winchman does not swing.

The helicopter will then move towards the transfer area. Now the deck crew must continue to take up the slack and on the signal from the winchman, haul him on board (Diagram 2). When the winchman is on the deck, he will disconnect himself from the winch hook and the helicopter will move away from the vessel. The deck crew should now pay out the Hi-line. The winchman will brief the deck crew on any requirements.

For recovery, the winch hook is pulled in board to allow the casualty and the winchman to be attached. They will then be lifted off the deck. The deck crew should retain tension on the Hi-line to prevent excessive swinging (Diagrams 3 and 4).

Once the winchman and casualty are inside the helicopter, the Hi-line will be recovered by taking up the Hi-line until only the weighted end is left on the vessel. The deck crew should clear the weighted end from all obstructions and the Hi-line will be fully recovered by the helicopter crew.

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IS 100% OXYGEN NECESSARY IN THE EMERGENCY MANAGEMENT OF DECOMPRESSION ILLNESS?

Chris Acott

Key Words

Accident, decompression illness, first aid, oxygen, retrieval, treatment.

Abstract

Surface oxygen is now considered an essential component of the emergency management of decompression illness (DCI). Data suggest an improvement in pre-treatment symptoms, however outcome data are inconclusive. Frequently the FiO_2 in the emergency management is unknown and perhaps any concentration of

oxygen greater than 0.21 (21%) would benefit the patient and simplify oxygen administration. These issues are discussed in this paper.

Fructus, in 1979, advocated that aspirin, parenteral steroids, fluids and 100% oxygen be used in the emergency management of DCI patients. There are some data to suggest that aspirin is detrimental to pre-treatment outcome but this effect can be negated by the use of steroids and fluids. There is, however, a debate in Australasia about how fluids should be administered and the controversy of oral administration compared with parenteral fluids is discussed in this paper.

Introduction

Bert advocated the benefits of normobaric oxygen in the management of decompression illness (DCI) in 1878.[1] Behnke calculated an eleven fold increase in nitrogen washout using 100% ($FiO_2 = 1$) normobaric oxygen in 1937.[2] The reasons for using 100% oxygen for the emergency care of DCI patients are shown in Table 1. Fructus in 1979 advocated the combination of oxygen, aspirin, parenteral steroids and fluids in the emergency care of DCI from data obtained in the 1960s and 70s.[3]

TABLE 1

THEORETICAL REASONS FOR THE USE OF 100% OXYGEN IN THE EMERGENCY CARE OF DCI

No additional inert gas
Maximum gradient for inert gas washout
Relieves hypoxia

Normobaric oxygen

100% surface oxygen was recommended in the emergency management of DCI in the late 1960's[3] but there are few data to suggest that it has improved the outcome following treatment.

Recent DAN data reported that 58% of divers who received emergency oxygen were symptom free following treatment compared with 55% of divers who did not receive emergency oxygen. However, 12% of divers who received emergency oxygen were symptom free at presentation for treatment whereas only 2% of divers who did not receive oxygen were symptomless. What was not reported was the length of time emergency oxygen was used and at what concentration.[4] Earlier data published by Fructus showed that there was an improvement in pre-treatment symptoms when either oxygen or the complete emergency care protocol (Tables 2, 3 and 4, on page 18) were used in emergency care, unfortunately there was no correlation between outcome following treatment and the use of oxygen.[3] The FiO_2 was not established in these data. However, Marroni's 1996 European DAN data indicated a better outcome following treatment if emergency oxygen was used.[5] These data are shown in Table 5.

TABLE 2

EMERGENCY CARE PROTOCOL (FRUCTUS 1979)

100% Oxygen
Fluids
Aspirin
Steroids

TABLE 5

MARRONI'S EUROPEAN DAN DATA 1989-1993

	Oxygen		**No Oxygen**	
	Divers	%	Divers	%
Total divers	119	59	83	41
Symptoms before treatment				
Resolved	14	12	1	1
Improved	66	55	0	0
Unchanged	39	33	82	99
Symptoms after treatment				
Full resolution	114	96	58	70
Sequelae	5	4	25	30

Fluid administration

No definite conclusions can be drawn from Fructus's data because of the small number (57) of divers involved, however, there is an indication that the addition of aspirin has a negative effect on the pre-treatment outcome which can, in turn, be negated by the addition of parenteral fluids (500 ml Dextran 40) and steroids (either hydrocortisone 1,000 mg or dexamethasone 30 mg or medrocortisone 160 mg).[3]

Diving has a dehydrating effect (up to a 10-12% reduction in the circulating blood volume)[6] and DCI induces plasma loss,[2,6,7] therefore, fluid replacement should be an essential component in the management of DCI.[7] Maintenance of the cardiac output and normal blood viscosity are important in the maintenance of epidural and

TABLE 3

CHANGES IN SYMPTOMS BY THE TIME OF TREATMENT (DENOTES NO CHANGE) (FRUCTUS 1979)

Symptoms	Complete protocol		Oxygen and aspirin		Oxygen		None	
Cerebral	12	(3)	1	(0)	2	(0)	8	(8)
Spinal	27	(7)	4	(2)	1	(0)	6	(6)
Mixed	6	(3)	0		0		0	
TOTAL	**45**	**(13)**	**5**	**(2)**	**3**	**(0)**	**14**	**(14)**
Unchanged symptoms	30%		40%		0%		100%	
Improved	**70%**		**60%**		**100%**		**0%**	

TABLE 4

DIVERS WHO WERE (ASYMPTOMATIC) AT THE TIME OF TREATMENT (FRUCTUS 1979).

Symptoms	Complete protocol		Oxygen and aspirin		Oxygen		None	
Cerebral	12	(6)	1	(0)	2	(1)	8	(0)
Spinal	27	(5)	4	(0)	1	(0)	6	(0)
Mixed	6	(0)	0		0		0	
TOTAL	**45**	**(11)**	**5**	**(0)**	**3**	**(1)**	**14**	**(0)**
Asymptomatic	**25%**		**0%**		**33%**		**0%**	

cerebral blood flow to prevent sludging and vascular stasis which hinder tissue and bubble inert gas washout. Parenteral fluid replacement (normal saline) has been clearly shown to be beneficial in an equivalent animal model of DCI, allowing a significantly better survival compared with none.[6] Data about fluid replacement is of parenteral administration and not oral.[3,6,7] The advantages and disadvantages of oral compared with intravenous fluid are listed in Tables 6 and 7.

Oral fluid replacement has a minimal place in emergency care and should only be used when IV fluid administration can not be achieved and an appropriate fasting time achieved before recompression treatment commences. Oral fluid must never be given to an unconscious or obtunded patient. The composition of the fluid used should be similar to that of the fluid lost and should not contain glucose/dextrose.[8] Its use should not interfere with oxygen administration, change the patient's first aid posture nor worsen the patient's clinical state (i.e. convert a nauseated patient to a vomiting one which will worsen the patient's dehydration).

TABLE 6

ADVANTAGES AND DISADVANTAGES OF INTRAVENOUS FLUIDS IN THE EMERGENCY MANAGEMENT OF DCI

Advantages

Direct into circulation
Fluid balance easier to calculate
Either crystalloid or colloid fluids can be used
Glucose containing fluids easily avoided
Can be used in nauseated, vomiting and obtunded patients
Do not present an aspiration risk in an epileptogenic environment of 2.8 bar oxygen
Can be used for rapid administration of medications if required
Patient's flat posture can be maintained
Does not interrupt oxygen administration

Disadvantages

Requires training, skill and revision of skills
Potential for fluid overload
Expensive

TABLE 7

ADVANTAGES AND DISADVANTAGES OF ORAL FLUIDS IN THE EMERGENCY MANAGEMENT OF DCI

Advantages
Inexpensive
Easy to administer

Disadvantages
Rely on gut absorption for access to the circulation
Fluid balance estimates inaccurate
Can not be given to obtunded or vomiting patients
Large amounts may cause vomiting in nauseated patients
Aspiration risk in an epileptogenic environment of 2.8 bar oxygen
Have to remove oxygen mask to give
If only given in air breaks large amounts are difficult to give
May need the patient to change posture to drink
Oral salt solutions are unpalatable or contain glucose and are not similar in composition to the fluid loss that occurs in DCI

Is 100% oxygen essential?

In the published data[3-5] the F_IO_2 was unknown (a substantial number would have been less than 1.0 or 100%) but many patients' symptoms had resolved by the time of treatment.

The Diving Incident Monitoring Study (DIMS) data, listed in Table 8, indicate some of the difficulties of administering 100% oxygen in the field.

Table 8 about here

TABLE 8

DIVING INCIDENT MONITORING STUDY [DIMS] FIRST AID DATA

38 reports analysed
In the majority the FiO_2 was unknown
Oxygen equipment was not checked; oxygen cylinders were found to be empty
A lack of knowledge on how to use the oxygen equipment
Inappropriate air breaks used
Resolution of symptoms in 50% of cases where was oxygen used
Oxygen was not administered in 20% of cases due to lack of equipment or other reasons

Administration of a lower F_IO_2 (less than 100%) would simplify oxygen administration by eliminating the need for air breaks, reduce the incidence of pulmonary oxygen toxicity, simplify and reduce the cost of the equipment needed. As the kinetics of gas elimination in a patient with DCI are unknown, any increase in the gradient for inert gas washout is likely to benefit the patient. Using a lower oxygen percentage will reduce the risk of the oxygen supply running out and so increase the time that increased oxygen is available.

Does lignocaine have a role?

Should a lignocaine infusion be commenced during transport to the nearest recompression facility? The answer will be evident once the role of lignocaine in the treatment of DCI has been established or refuted.[9] If lignocaine's role is established then an infusion could be commenced provided the necessary monitoring and resuscitation equipment are available.

Conclusions

Training for emergency care should always be aimed at the management of the worst case scenario thus enabling the first aid provider to manipulate his or her management to suit each situation. Intravenous fluid replacement should be encouraged and training courses established to achieve this. However at present such courses are not available for recreational divers in Australasia. Oral fluid administration guidelines need to be agreed upon and issued.

The theoretical advantages of the administration of 100% oxygen in the emergency care of any diving injury are well known, however, there are limited data that suggests it improves post-treatment outcome.

An F_IO_2 of 1.0 (100%) is difficult to achieve and the equipment required is expensive. Oxygen administration would be simplified if an F_IO_2 of less than 1.0 was used and cost of the equipment would be less.

The role of parenteral steroids and lignocaine in the emergency care of DCI is not yet established.

References

1 Bert P. *Barometric pressure* (1878). Translated by Hitchcock MA and Hitchcock FA. Columbus, Ohio: College Book Company, 1943. Republished Bethesda, Maryland: Undersea Medical Society, 1978
2 Behnke AR and Shaw LA. The use of oxygen in the treatment of compressed air illness. *Naval Medical*

Bulletin 1937; 35: 61-73
3* Fructus X. Treatment of serious decompression sickness. In *Treatment of serious decompression sickness and arterial gas embolism. 20th UMS Workshop*. Davis J. Ed. Bethesda, Maryland: Undersea Medical Society, 1979; 37-43
4 *The annual review of recreational scuba diving i njuries and deaths based on 1995 data*. Durham, North Carolina: Divers Alert Network (DAN), 1997
5 Marroni A. The Divers Alert Network in Europe. Risk evaluation and problem management in European recreational diving population. In *Handbook on Hyperbaric Medicine*. Oriani G, Marroni A and Wattel F. Eds. Berlin: Springer-Verlag, 1996; 265-276
6 Dutka AJ. Therapy for dysbaric central nervous system: adjuncts to recompression. In *Management of Diving Accidents.* Bennett PB and Moon RE. Eds. Bethesda, Maryland: Undersea and Hyperbaric Medical Society, 1990; 194-221
7 Seyer J. Pre-hospital treatment of decompression sickness in recreational divers. In *Handbook on Hyperbaric Medicine*. Oriani G, Marroni A and Wattel F. Eds. Berlin: Springer-Verlag, 1996; 187-191
8 Warner DS. Principles of resuscitation in CNS injury and future directions. In *Treatment of decompression illness. 45th UHMS Workshop.* Moon RE and Sheffield PJ. Eds. Kensington, Maryland: Undersea and Hyperbaric Medical Society, 1996; 374-388
9 Dutka AJ. Serious decompression injury: pharmacological aids to treatment. In *Treatment of decompression illness. 45th UHMS Workshop.* Moon RE and Sheffield PJ. Eds. Kensington, Maryland: Undersea and Hyperbaric Medical Society, 1996; 127-139

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OXYGEN ADMINISTRATION IN DIVING ACCIDENTS

David Komesaroff

Key Words

Accidents, equipment, first aid, oxygen, rescue.

Introduction

Oxygen administration in diving accidents has been well documented.[1] However the importance of duration of oxygen supply, humidification and temperature of inspired oxygen and pain relief has often been overlooked.

Basal (resting) physiological oxygen requirements of an adult are approximately 250 ml/min (3 ml/kg). Activity, body temperature and the presence of pain increase this. 2 l/min is about the maximum possible oxygen utilisation (measured in athletes following a 100 m sprint).

In demand valve resuscitators, high flow rates of oxygen are used to flush the exhaled carbon dioxide to the atmosphere. This has several disadvantages.

Approximately 10 l/min of oxygen are required.

The inhaled oxygen is dry and cold.

Sterilisation of equipment after use is inconvenient or impossible.

In closed circuit resuscitation systems less oxygen is used as expired carbon dioxide is removed by an absorbent, for example soda lime or baralyme.

Oxygen supply

A demand valve system requires a fresh gas flow in excess of 10 l/min. A demand valve system with manual triggering for the non-breathing patient (Manually Triggered Ventilator or MTV) will require more. C Size portable oxygen cylinders (2.84 l water volume) contain about 400 litres of oxygen, so a cylinder change is necessary about every 30 minutes. It is therefore essential to have available either multiple C size cylinders or a larger non-portable D (9.5 l water volume), containing about 1,600 l, or E (23.8 l water volume), containing about 2,200 l, size cylinder.

A closed circuit system (such as the OXI-dive1™) theoretically requires a fresh gas flow of about 0.25 l/min but in practice about 3 l/min is needed to achieve 100% inspired oxygen in a diving accident victim. A portable cylinder will last about 120-130 minutes. In experienced hands the closed circuit system requires only 1-2 l/min equating to approximately four hours supply of oxygen.