

Proposing short-term observation units for the management of decompression illness.

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Tempel R., Severance H.W. Proposing short-term observation units for the management of decompression illness. *Undersea Hyperb Med* 2006, 33(2):89-94. Decompression illness (DCI) is a potentially life-threatening disease, often requiring hyperbaric oxygen therapy (HBO₂) for symptom resolution. Once treated, current guidelines recommend an observation period of at least six hours for patients with neurological symptoms in case of relapse. Surveys have shown a symptom relapse rate as high as 38.5%, with half of those occurring in the first twenty-four hours. We propose that a short-term observation unit (OU) would be an ideal setting for these patients to be monitored. To evaluate this, we did a retrospective study of patients presenting with DCI at a major hyperbaric facility. One hundred and two consecutive patients were evaluated with DCI diagnosis and receiving HBO₂. Forty-two (41.2%) patients had neurological sequelae; ten required more than one treatment for refractory symptoms or relapse. Thirty-eight of the forty-two patients received up to three treatments, which can be done within the time requirements of short-term observation. We conclude that OUs would provide a safe and efficient disposition for patients after receiving HBO₂.

INTRODUCTION

Underwater diving with SCUBA continues to increase in popularity, in both fresh and saltwater. While numbers concerning commercial diving are not well documented, the Professional Association of Diving Instructors (PADI) estimates that one million new scuba divers are certified annually. The Divers Alert Network (DAN) began recording dive injuries requiring hyperbaric oxygen therapy (HBO₂) in 1987 (1). On average there are more than 1,000 reported injured divers annually since 1993 (2). One potentially life-threatening risk of scuba diving is Decompression Illness (DCI), which includes both *in situ* gas bubble formation, known as decompression sickness (DCS), and arterial gas embolism (AGE) from pulmonary barotrauma (3). The arterial transit of bubbles formed in the venous system may occur via a patent foramen ovale, leading to additional injury. The mechanism by which gas bubbles cause injury can be both immediate and

delayed. Initially, vascular occlusion and tissue disruption with subsequent mediator release may impair blood supply (4, 5). Secondary changes include platelet and leukocyte aggregation as well as fibrin deposition at the site of injury. Intravascular bubbles may increase capillary permeability, resulting in significant capillary leak and hemoconcentration (6). Neurological injury may be initiated by cerebral arteriolar occlusion, however secondary cerebral edema may also be responsible for symptom presentation and duration (7).

While the management of DCI may include supplemental normobaric oxygen, intravenous fluid replacement and anti-inflammatory agents, the mainstay of treatment is therapeutic recompression while the patient is breathing oxygen under pressure. The use of hyperbaric oxygen therapy (HBO₂) is relatively safe and effective with symptom relief often occurring during the first treatment. Nearly all patients are symptom-free after three treatments

(2). The United States Navy (USN) has provided treatment tables and recommendations for observation after treatment in case of relapse (8). For patients with residual symptoms, the US Navy recommends transfer to an appropriate medical facility, and persistent neurological symptoms be treated with daily HBO₂. The US Navy Diving Manual states that patients who have had complete relief of symptoms remain at the recompression chamber facility for up to six hours (8). Some authors recommend admitting all recompressed patients or advising they stay within one hour of a hyperbaric facility for twenty-four hours (9).

Most DCI injuries are non-life threatening, yet expert guidelines require observation after the initial evaluation and treatment for the risk of symptom relapse. Patients were often admitted to the hospital or returned to the facility's ED after receiving HBO₂ for observation. Many facilities utilize other options, including discharge home with family or to a local hotel, requiring return in the morning to report their progress. Due to increasing concerns of medical liability, massive ED overcrowding, and reduced inpatient staffing, these choices may not be optimal.

While there is little published information on relapse rates after HBO₂, examples have been documented (14). A review of the British Royal Navy's treatment of AGE revealed a relapse rate of 33.9% (7). A recent study found a 10% relapse rate among DCI patients who flew after complete symptom relief from HBO₂ (15). While it is clear that patients who fly soon after recompression are at increased risk for relapse, several surveys show those who stay on the ground are also at risk. A survey of hyperbaric facilities in August 2003 found a relapse rate of 3.6% among treated divers, while an online DAN survey of divers treated for DCI in October 2003 noted a relapse rate of 38.5%. The discrepancy in relapse rates is

significant, and may be due to how each subject defined 'relapse'. These examples exhibit the unreliability of a survey to evaluate this issue. A thorough review of all literature studying DCI relapse found that 50% of relapses occurred on the first day after recompression (14). Therefore, a protocol to monitor patients who presented with concerning neurological symptoms in an observation unit would be beneficial. It would also allow emergency department physicians to complete a medical workup on these patients after therapy to identify any other concerns.

Short-term observation units (OUs) provide physicians the opportunity to diagnose several 'time-sensitive' conditions, helping to prevent inappropriate discharges and unnecessary admissions (10). Approximately 93% of these units are located within the ED and staffed by emergency physicians (11). While no information exists concerning community-based EDs, nearly two-thirds of academic EDs with residency programs have or are planning an OU (12). To determine which patients would be best-suited for an OU, one should develop proper selection criteria and risk stratification tools, such as those available for patients presenting with chest pain (13).

In 2000, 80% of divers with DCI required no more than three treatments (2), which can potentially be done in about twenty-four hours. There is no published data considering DCI patients as candidates for an observation unit. In an OU, patients may continue to receive intravenous fluids, anti-inflammatory agents, and may be monitored by medical personnel. Most DCI patients have fully recovered within twenty-four hours of initial treatment; therefore they would seem excellent candidates for short-term observation.

METHODS

A retrospective search of the patient database at the Center for Hyperbaric Medicine

and Environmental Physiology at the Duke University Medical Center was conducted by one of the authors (RT), for all patients seen with a diagnosis of Decompression Illness between August 1, 1998 and July 31, 2004. The patient files were then examined and all patients who received hyperbaric oxygen therapy were retained. Using the patients' medical record number, the full hospital course for the patient was extracted from the Duke University Patient Medical Database, or 'eBrowser'. Once information was identified, patients received a random numeric code assignment to protect privacy. Information extracted included date of consult, symptoms on presentation, type and number of recompression treatments utilized, length of stay, and disposition after hyperbaric therapy. Patients were divided into two categories with symptom presentation: mild (single extremity pain and/or weakness) and significant (pain or weakness in 2 or more extremities, loss of consciousness, altered mental status, cognitive deficits, ataxia, dizziness, severe headache). Patients were again divided into four criteria based on disposition after hyperbaric therapy: admission, discharge, returned to ED, or observation department.

RESULTS

Between August 1, 1998 and July 31, 2004, a total of 102 patients were diagnosed

with decompression illness and treated with hyperbaric oxygen therapy by the Duke University Center for Hyperbaric Medicine and Environmental Physiology. (See Table 1) Sixty patients presented with only single extremity pain and weakness, while forty-two patients exhibited neurologic sequelae concerning for cerebral or spinal cord insult. In addition, one patient with neurological injury also had evidence of cardiac insult.

Eighty-two patients received US Navy Treatment Table 6 for initial therapy, while twenty patients received Table 5. Ninety-eight patients received up to three treatments, and four patients received four or more treatments. Of the forty-two patients with neurological sequelae, 32 had symptom resolution with a single treatment. Six patients required 2-3 treatments, and 4 required more than 4 treatments with HBO₂ due to symptom relapse.

Dispositions were as follows: eighty-two patients were discharged home or to a nearby hotel directly from the hyperbaric department, without emergency department documentation of a return. Of the forty-two patients presenting with symptoms indicative of central nervous system insult, twenty-six were discharged directly from the hyperbaric department shortly after treatment. All twenty-six have documented follow-up appointments or phone conversations, and no adverse outcomes were documented. Eight returned to

Table 1. Patients treated with hyperbaric oxygen therapy for decompression illness (N=102).

	Mild Symptoms	%	Neurological symptoms	%	% Total
Total	60	58.8	42	41.2	100
Received TT5	20	33.3	0	0	19.6
Received TT6	40	66.7	42	100	80.4
One Treatment	58	96.7	32	76.2	88.2
2-3 treatments	2	3.3	6	14.3	7.8
4+ treatments	0	0	4	9.5	4.0
Discharged home/hotel	56	93.3	26	61.9	80.4
Returned to ED	4	6.7	7	16.7	10.8
Admitted	0	0	8	19.0	7.8
Observation unit	0	0	1	2.4	1.0

the ED for observation before discharge, seven were admitted, and one was placed in the observation unit.

The patient placed in the OU had developed sudden ear pain, nausea, and vertigo while surfacing from a no-decompression dive. Examination and laboratory results revealed that the patient was also significantly dehydrated, as evidenced by a hematocrit greater than 50 and mild tachycardia. It could not be determined if the patient's symptoms were due to inner ear barotraumas or DCI, therefore the patient was monitored overnight in the short-term observation unit under a 'dehydration' protocol. The patient was treated with intravenous fluids and anti-inflammatory medication. The ear pain and vertigo did not resolve overnight, and the patient was then placed in the hyperbaric chamber. The symptoms fully resolved with a USN TT6, and the patient was returned to the OU after therapy. There was no relapse of symptoms and the patient was discharged home within twenty-four hours of presentation.

DISCUSSION

The goal of this study was to propose the use of observation medicine in the treatment and disposition of patients with decompression illness, with particular emphasis on central nervous system injury. As this was a retrospective pilot study, further work will be needed to see if this is an effective option. Future studies looking at cost-analysis or DCI relapse detected in an OU would further strengthen such a proposal.

It is unknown at this time how many hyperbaric medicine facilities have access to an observation department for patient disposition. A survey of these departments, including whether or not they have used an OU for patients before, would help strengthen the utility of this study.

This study was performed at a large

university referral-based medical center, and therefore we suspect the number of more serious injuries may be higher than other facilities. Some ED-based hyperbaric facilities with an OU are already using it for DCI, yet no protocol exists for these patients. Based on these limitations, we propose a protocol be established for the short-term observation of DCI patients, and a prospective case-controlled study utilizing that protocol be performed, with additional cost-benefit analysis.

Finally, the risks and rate of relapse in patients with DCI continues to be controversial. The time-course and pathophysiology concerning relapse are not fully understood. Perhaps when further studies are available, we will see additional indication for post-recompression observation.

This was a retrospective study to propose short-term observation for the management of patients who received HBO₂ for DCI. Of the forty-two patients presenting with neurological symptoms from DCI, 10 required more than one treatment. Six of those 10 patients required three or less treatments, which can occur in less than twenty-four hours and be done in a short-term observation unit. We conclude that DCI patients may benefit from short-term observation to identify those who develop symptom relapse. This is particularly important in those with neurological sequelae, who may be at increased risk for injury if they should relapse after being discharged. We have proposed initial management techniques, treatment, and disposition for patients presenting with concern for DCI.

Decompression illness is a disease encompassing both intrinsic gas bubble formation and pulmonary barotrauma. Major debilitating diving injuries, such as pneumothorax and arterial gas embolism, may require urgent intervention. Therefore, all patients presenting with symptoms consistent with DCI should first be evaluated

per Advanced Trauma Life Support (ATLS) protocol. First assessing the patient's airway, breathing, and circulation would best evaluate emergent conditions. Current medical literature recommends that all patients with suspected arterial gas embolism should have an electrocardiogram, creatine kinase and troponin drawn to evaluate for possible coronary embolization (16). Patients should receive hyperbaric consultation once they have been cleared from other major trauma. Cardiac arrest requires Advanced Cardiac Life Support (ACLS), followed by USN TT6. Patients may continue to receive ACLS while in the hyperbaric chamber, but note that recompression chambers must be surfaced to perform defibrillation⁸. A symptom-oriented history and physical examination should take only a few minutes and would put no significant delay in getting the patient to the hyperbaric chamber. Our proposed OU protocol recommends that patients with significant neurological sequelae, if not admitted to the hospital, be returned to the ED or directly to the OU after HBO₂ for additional necessary care (Appendix 1). Potential OU interventions include oxygen supplementation, intravenous hydration, analgesia, and cardiac echo to evaluate for patent foramen ovale (17). The emergency physician may discharge the patient home if symptoms do not recur, or may contact the hyperbaric medicine personnel if continued HBO₂ is needed.

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Appendix 1: Proposed Observation Unit Protocol for Decompression Illness

- I. Inclusion Criteria**
 - a. History of underwater diving
 - b. History of high-altitude flying
 - c. Weakness or sensory change
 - d. New onset cognitive deficit, ataxia, vertigo, or headache
 - e. Indication for hyperbaric oxygen (HBO) therapy consultation

- II. Exclusion Criteria**
 - a. Hemodynamic instability
 - b. Paralysis
 - c. Seizures
 - d. EKG changes or positive biomarkers consistent with cardiac injury
 - e. Critically abnormal labs (potassium, acidosis)

- III. OU Interventions**
 - a. Observation between HBO treatments
 - b. Serial neurological evaluations and vital signs
 - c. Cardiopulmonary monitoring
 - d. IV hydration and medications
 - e. Oxygen via nasal cannula or facemask

- IV. Disposition**
 - a. Home
 - i. Resolution of symptoms
 - ii. No change in symptoms with repeat hyperbaric oxygen therapy
 - iii. Stable vital signs
 - iv. Cleared by hyperbaric medicine for discharge
 - b. Hospital
 - i. Requiring more than 3 HBO treatments for symptoms
 - ii. Deterioration in respiratory, hemodynamic, or neurological status

- V. Time Frame**
 - a. 8-16 hours