Delay to Recompression

The most effective treatment for decompression sickness (DCS) and arterial gas embolism (AGE) caused by gas bubbles that occur after decompression is the return of the patient to an environment of increased pressure. This is called recompression. Ideally a patient can be recompressed within minutes of symptom onset — bubbles would be quickly eliminated, and symptoms would resolve. This occurs sometimes in commercial and military diving. However, in recreational diving, even when a chamber is available locally, it generally takes hours rather than minutes to begin recompression treatment. If a hyperbaric chamber is not available locally, which is often the case, recompression may be delayed for days. For divers in remote locations, the question of the impact of the length of delay to recompression on their chances of a complete recovery is an important one. In asking this question, it is also important to explore steps that can be taken to mitigate risks. The available data do not provide straightforward answers, so we turn to experts for advice.

What determines the degree of emergency in DCS?

Dr. Jordi Desola: The degree of emergency in cases of DCS is determined by the severity of its presentation. Severe cases involve several organ systems and may involve impaired circulation, breathing and consciousness. Such cases can result in permanent disability or death.

Dr. Karen Van Hoesen: The following responses represent the collective opinions of the University of California San Diego (UCSD) Hyperbaric Medicine Center physicians. These opinions are based on review of the literature and our collective experience of treating divers with DCS for more than 30 years. In general, the degree of emergency in DCS is determined by 1) the time to onset of symptoms following the dive, 2) cardiopulmonary instability and 3) rapidly progressing neurologic symptoms. The quicker the onset of neurologic symptoms after a dive (including motor and cerebellar symptoms and mental status changes, but not including sensory deficits alone), the more serious the DCS insult. Any evidence of cardiopulmonary instability with DCS is a true emergency. Neurologic symptoms that present quickly and rapidly progress are also an indication of serious DCS and should be considered an emergency. AGE with neurologic symptoms is a true emergency and is excluded from the responses that follow.

In your opinion, starting at six hours after symptom onset, how much additional delay to recompression may affect the outcome of DCS?

Van Hoesen: Based on very limited case reports and data, it appears there is a subset of moderate to severe DCS cases where early treatment within six to 12 hours may improve outcome. However, this subset of individuals with DCS has not been clearly defined. The severe cases described above may make up part of this subset. Regardless, there are numerous cases of DCS that show improvement even with significant delay to treatment beyond 24 hours.

Desola: I have worked in Barcelona’s hyperbaric unit for more than 30 years and have treated several hundred DCS cases of various severities and with various delays to treatment. In 1977 we started a prospective study to explore what affects the outcome of treated DCS. The first analysis of 466 cases, presented in 1997, showed that delay in recompression was not significant. Three years later and with more cases (554), a comprehensive statistical analysis revealed that clinical findings are the most important prognostic factors for DCS outcome. Our findings were not very popular because they went against current beliefs at that time. Since then, several reports from reputable hyperbaric centers have confirmed them. A recent retrospective study in the French navy found that 25 percent of divers with DCS had incomplete resolution after one month despite a short delay to recompression (median 35 minutes).

Longer delays apparently did not significantly increase the risk of incomplete resolution. A critical factor in good outcomes in severe DCS is the quality of the combined treatment: drug therapy, aggressive rehydration, hyperbaric oxygen therapy and critical care assistance inside the chamber when necessary.

Might the effects of a delay to recompression affect severe and mild DCS differently?

Desola: Experience suggests that the more serious the signs or symptoms, the worse the prognosis, regardless of the delay to recompression. It was believed more severe cases could be completely resolved if recompressed within the first few minutes, but this is rarely possible, even in military or professional diving and never in recreational diving. On the other hand, most mild cases resolve completely regardless of treatment delay.

Intuitively, recompression must be applied as soon as possible, within the rational local limitations. This is the message that must be given to divers at all times. However, today we know of many divers recovering satisfactorily despite having received hyperbaric oxygen therapy (HBOT) hours or even days after onset of the symptoms. In contrast, there are also cases of DCS with a poor outcome despite being treated within few hours after symptom onset.

Van Hoesen: It may. As described above, there is probably a subset of patients with more severe DCS that do better with early treatment. The natural history of mild DCS is that it tends to improve with time regardless of time to treatment. HBOT should still be considered the standard of care for all cases of DCS.

Considering the increased risk of accidents with unscheduled flights, what conditions must a patient meet for you to decide to use an emergency air evacuation versus a scheduled flight on a commercial aircraft or ground transportation?

Van Hoesen: Each case of DCS needs to be considered individually and should be discussed with a DAN medic or consulting physician. Anyone meeting the criteria for severe DCS described above should be considered a candidate for emergency air evacuation. Ground transportation for individuals with mild, pain-only DCS may be suitable. Flying on a commercial airliner with mild, pain-only DCS might also be the most appropriate approach, depending on the situation.

Desola: If divers' vital functions are stable and no life-threatening complications are expected, they may be transported with a scheduled flight on a regular airliner. This includes cases of skin and muscular DCS, mild neurological DCS and even spinal cord DCS in which the lesion is likely incomplete, affecting only mobility and/or sensitivity of the limbs without causing bladder or bowel paralysis. The patient must be in stable condition. Also, the patient must be rehydrated before transportation and should breathe oxygen during transportation. In cases of pulmonary barotrauma with pneumomediastinum or pneumothorax, divers should not travel aboard a regular airliner due to the risk of life-threatening conditions from further expansion of gas trapped within the chest.

If divers with DCS symptoms have no chance of reaching a hyperbaric chamber without delay, what should they do in the meantime?

Desola: This is a difficult question; a very detailed and complete evaluation over the phone or via video conference is essential. The procedure will be different depending on the assessed seriousness of the diver's injury.

Noncritically Injured Divers

Injured divers who are in stable condition and whose symptoms are no more severe than muscle pain,

fatigue, mottled skin or impaired sensation in an extremity can be considered noncritically injured. These patients must not have any serious symptoms such as bowel or bladder paralysis.

A local physician or medical facility, if available, should be contacted to examine and evaluate the diver.

If no medical help is available locally, a detailed phone evaluation should be conducted.

Provided the injured diver is conscious, oxygen and oral rehydration should be administered, and a low dose of an anxiolytic and/or analgesic could be considered if needed.

An air evacuation should be organized using the first available commercial or private aircraft. The patient should be transported to a hyperbaric facility that can provide adequate medical care. The facility should be within a hospital and so may not be the nearest hyperbaric chamber.

Telephone contact with the target hospital-based hyperbaric facility must be initiated.

Critically Ill or Injured Divers

This applies to cases in which there is bladder paralysis, shock (low blood pressure, hemoconcentration and hypovolemia), possible changes in consciousness or respiratory failure. This includes severe cases of DCS as well as AGE caused by pulmonary barotrauma and nonfatal drowning.

Confirm the diagnosis, and re-evaluate the severity of the injured diver's clinical condition.

Transfer the seriously injured diver to the nearest available hospital that can provide qualified evaluation and proper emergency care despite the fact that a hyperbaric chamber with an experienced hyperbaric physician may be closer.

In the hospital, a physician will apply necessary emergency procedures to ensure the patient's survival. DAN emergency medical services should be contacted (+39 06 42118685), and the best procedure regarding hyperbaric treatment should be decided. In some cases it may include a medical air evacuation to the most appropriate hospital when the patient's status permits it.

Van Hoesen: Divers with DCS symptoms should breathe surface oxygen if available. If the diver is conscious, awake and alert, he should drink fluids and stay well hydrated. If pain is the only symptom, taking a nonsteroidal anti-inflammatory medication such as ibuprofen or naproxen can be considered. The diver should avoid alcohol intake. Do not initiate in-water recompression.

NOTE: *Regardless of the opinions expressed herein, each case of DCS should be discussed on an individual basis with DAN medical staff to ensure proper diagnosis, treatment and evacuation, if indicated. Additionally, these opinions are for recreational divers and do not apply to technical, mixed-gas, commercial or saturation divers.*

December 2013

Meet the Experts

Jordi Desola, M.D., Ph.D., is the head of the Hyperbaric Therapy Unit of the Red Cross Hospital of Barcelona (Catalonia, Spain). His specialties are internal medicine, occupational medicine and sports medicine. He is professor of diving and hyperbaric medicine at the University of Barcelona, cofounder of DAN Europe and a permanent member of the executive committee of the European Committee for Hyperbaric Medicine

(ECHM). He was chairman and president of the 15th International Congress on Hyperbaric Medicine (ICHM) in 2005. He is also a diving instructor and a pilot.

Karen Van Hoesen, M.D., is the director of the University of California San Diego (UCSD) Diving Medicine Center and Undersea and Hyperbaric Medicine Fellowship. She is a clinical professor of emergency medicine in the UCSD Health System and has authored numerous papers and book chapters on diving and hyperbaric medicine. She is an active diver and one of DAN's on-call consulting physicians.