Aerospace Medicine Clinic

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You are a U.S. Air Force (USAF) flight surgeon called away from clinic to evaluate a potential case of decompression sickness (DCS) at the base hypobaric chamber. On arrival, you find a healthy-appearing 25-yr-old aerospace and operational physiologist. He reports acting as an inside observer for an altitude chamber training sortie.

The patient claims that he followed an unremarkable 30-min oxygen pre-breathe protocol and the chamber depressurized to 7620 m (25,000 ft) without incident. The chamber protocol then decreased the altitude to 5486 m (18,000 ft). On beginning this descent, the member immediately experienced sudden blurriness of his left visual field, accompanied by scattered bilateral flashes of light. He was on 100% oxygen at the time of the symptoms as part of his inside observer duties. The patient alerted colleagues and the chamber was returned to ground level. The patient remarks that he was asymptomatic by return to ground level and his symptoms lasted approximately 5 min. He remained asymptomatic for the 30 min prior to your arrival.

The patient is currently lying on a cot and on room air. Physical exam, including focused neurological and eye exams as well as vital signs, is unremarkable. The patient denies any recent illness, but admits to a history of migraines that was previously undisclosed to the military. He has noted variable symptoms with his migraines, including visual auras, but that he has never experienced symptoms in the altitude chamber until this day.

1. Which of the following is true regarding migraine auras?
   A. Auras are always visual.
   B. Migraine auras typically last between 1-2 h.
   C. You can have a migraine aura without classical headache features.
   D. Over 50% of patients with migraines experience auras.

ANSWER/DISCUSSION

1. C. A migraine aura is a focal sensory symptom that is associated with the early stages in the development of a migraine attack. Over 20–40% of people who experience migraines report auras.[3] Auras are most commonly visual and can be both positive and negative. Examples include a patient reporting a visual deficit accompanying a headache (a negative symptom) or new flashes of light (a positive symptom). Auras can also be auditory, somatosensory, or some combination of these symptoms. Auras typically develop within 5 min and resolve in under 1 h.[5] An acephalgic migraine is a type of migraine that lacks typical headache features, potentially making it more difficult to diagnose. It is estimated that 4% of people with migraines exclusively have this variant.[16]

2. What would be the best next step in management of this patient?
   A. Symptoms have resolved, so no further treatment is required.
   B. Place the patient on oxygen and coordinate evaluation for potential hyperbaric oxygen therapy (HBOT).
   C. Provide the patient a prescription for abortive migraine medication.
   D. Observe the patient in clinic.

ANSWER/DISCUSSION

2. B. Anyone reporting new symptoms after a recent altitude exposure needs initial assessment and treatment for DCS until the condition is ruled out. It is generally accepted that the risk of DCS in aviation begins at 7620 m (18,000 ft), where aviators experience the equivalent of one-half atmosphere of pressure.[17] This patient's visual symptoms raise concerns of neurological DCS, a more severe (Type II) variant of DCS. Getting a patient to definitive HBOT care for further evaluation is the most important step, but in the meantime, the aviator should be placed on 100% oxygen via whatever means can deliver the highest oxygen concentration to the patient.[9] In flightline response situations, this may mean using a tight-fitting aviator mask, but in the typical clinic, this will usually be a nonrebreather mask.

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Oxygen is an integral part of DCS treatment. Using 100% oxygen facilitates diffusion of oxygen to any hypoxic tissues and presents nitrogen bubbles with a gradient, encouraging nitrogen to diffuse out of the bubble, reducing its size.[14,19] HBOT couples these benefits of oxygen with increased pressure. Boyle's law describes an inverse relationship between pressure and volume. By increasing the pressure, the volume of the nitrogen bubble is further reduced.[10]

The damaging effects of DCS extend beyond gas bubbles themselves. Bubbles in the vasculature cause significant endothelial damage and systemic inflammatory responses, such as neutrophil activation and increased cytokines. HBOT appears to upregulate antioxidants and make endothelial cells more resistant to the oxidative stresses associated with inflammation in DCS.[7]

3. What demographic characteristic or other patient factor is most likely to increase the odds of developing altitude DCS?
   A. Female sex.
   B. Younger age.
   C. Higher exertion levels at altitude.
   D. Obesity.

ANSWER/DISCUSSION

3. C. The four primary variables impacting altitude DCS risk are altitude, time at altitude, preoxygenation time, and the level of physical activity.[15] The USAF Research Laboratory used decades of research data to create the Altitude Decompression Sickness Risk Assessment Computer, a validated tool to help clinicians and researchers determine the theoretical risk of DCS based on these four factors.[15]

Several demographic and other factors are classically associated with increased risk of developing DCS at altitude, but these appear less important for aviators than for underwater divers. Nitrogen stores accumulate and are slower to dissipate from adipose tissues than lean muscle. There are established relationships between obesity and DCS risk in commercial and military divers who may spend days and weeks at depth.[11] However, the relationship of obesity alone with altitude DCS has not been firmly established in the literature. A 2005 review of physiological and anthropometric factors with altitude DCS only identified a positive correlation of elevated body mass index when combined with poor physical conditioning. Even this combined variable accounted for only a small percentage of the overall altitude DCS risk.[21]

While women were thought to be at increased risk of DCS due to higher levels of adipose tissue, sex has not been associated with impacting DCS risks in an aviation environment.[20] Meanwhile, there does appear to be an association with older age elevating the risk of altitude DCS.[17]

Unlike the other answer choices, exercise at altitude and during a decompression event is well established with increased risk of developing DCS.[17] Pre-breathing oxygen prior to altitude exposure can also offer DCS protection. Astronauts and the U-2 community combine these variables to their advantage. They will exercise during oxygen pre-breathing, helping to synergistically facilitate a nitrogen washout.[17] In general aviation, the Federal Aviation Administration recommends that aviators avoid unnecessary strenuous activity before and 24 h after unpressurized flight to over 5486 m (18,000 ft) as additional DCS risk mitigation.[2]

Following the flight surgeon's initial assessment, the member was placed on 100% oxygen and transported via ambulance to a medical center with HBOT capabilities. In consultation with the USAF Hyperbaric Medicine Consultant, the patient was treated with U.S. Navy Treatment Table 6 and remained asymptomatic. Neurological and cardiovascular evaluations at the USAF Aeromedical Consult Service elicited a diagnosis of acephalgic migraines. The Altitude Decompression Sickness Risk Assessment Computer would place the risk of developing DCS in his case at under 1% based on altitude, duration, and the 30-min oxygen pre-breathe. However, HBOT is low risk when compared to untreated DCS.

Civil aviation and U.S. military branches vary in regard to guidance for returning aviators to flying after a DCS event. For the USAF, aviators without neurological or pulmonary symptoms can be returned to flying duty by the local flight surgeon—without a waiver—if symptoms have been resolved for 72 h and total symptomatic involvement was under 2 wk. Aviators with non-neurological and non-pulmonary symptoms lasting more than 2 wk should receive symptom-focused exams by appropriate specialists and a waiver is required. All cases with central nervous system or pulmonary involvement require a waiver and review by the USAF Aeromedical Consult Service. If diagnostic studies and subspecialist evaluations are all normal, a waiver may be granted after a 1-mo grounding period. If any abnormalities are found, the grounding period must be a minimum of 6 mo.[6]

The U.S. Army adjudicates DCS cases by single versus recurrent episodes and whether the DCS is Type I or Type II. Aviators with single-episode Type I DCS require no waiver and must be symptom free for a minimum of 72 h. Recurrent or Type II DCS is disqualifying for initial aviation applicants, and trained aviators may be waived after full symptom resolution and a 1-mo waiting period.[18]

In the U.S. Navy, a history of any DCS without residual symptoms is not disqualifying. Type I DCS requires 3 d asymptomatic grounding, and Type II DCS requires 14 d of asymptomatic grounding. History of Type II DCS with residual symptoms can be considered for a waiver on a case-by-case basis after appropriate subspecialist disposition.[12]

The Federal Aviation Administration offers no specific guidance regarding a history of DCS in the Guide for Aviation Medical Examiners.[4] Nonprogressive neurological conditions are listed as potentially suitable for Special Issuance consideration, and a case report published by a resident at the Civil Aerospace Medical Institute describes a pilot who received a Statement of Demonstrated Ability for residual lower extremity deficits following a Type II DCS event.[13]

The member was allowed to remain an aerospace and operational physiologist but was permanently disqualified from flying or inside observer chamber duties. Specialists expressed

concerns about potential associations of his migraines with barometric pressure changes or hypoxia, known potential triggers of episodic migraines, as well as difficulty discerning if future events are DCS or migraines.[1,8]

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