The ears have it

DIVER 1

The Diver

This 25-year-old man has been diving for two years and has logged 12 dives in the past year. At the time of the incident, he had no significant medical history and was taking no medication.

The Dive Profile

He made his dives in warm waters (80 degrees F / 27 degrees C) with minimal current. Dive #1 went to 50 feet (15 meters) for 45 minutes. This was a multilevel dive, but the diver later noted that he spent most of the dive at 30 feet (9 meters). The surface interval was one hour. Dive #2, also a multilevel dive, went to 40 feet (12 meters) for 50 minutes. Through most of the dive he remained at 25 feet (<8 meters).

The diver reported that he experienced some difficulty equalizing his ears during the first dive. On the surface interval, he said that his ears felt congested. He had the same clearing difficulty on the second dive, estimating that it took approximately 10 minutes to equalize his ears on descent. Thirty minutes after the dive, he was disassembling his gear and noticed his ears still felt congested. He performed a Valsalva maneuver to clear them and reported an immediate onset of tinnitus (ringing) and vertigo/dizziness. His symptoms remained consistent, neither growing nor diminishing, until he reached a medical facility where he could receive more definitive evaluation and care. On exam, he had redness in his tympanic membrane (eardrum) and the airspace behind his drum seemed to be pushing the eardrum outward. Both effects are signs of trauma and overinflation.

Test Your Knowledge

1. *What is the most likely diagnosis?*

A. Middle ear barotrauma
B. Inner ear barotrauma
C. Inner ear decompression sickness

2. *What would be the best treatment?*

A. None
B. Oxygen alone
C. Hyperbaric treatment
D. Bed rest with head elevated
E. Doctor appointment & possible oral deconge stants and nasal sprays

The Discussion

The dive profile for this particular day was not very provocative, so this diver's risk of decompression sickness was fairly low. He also reported trouble equalizing. Let's consider his profile. Divers who experience immediate vertigo, tinnitus and a feeling of ear congestion may have inner ear barotrauma. Unless there are also signs or symptoms of air embolism (cerebral signs such as loss of consciousness, confusion) or decompression sickness (typical joint pains and, vestibular symptoms, such as the inability to coordinate muscular movements), then hyperbaric treatment is not recommended. This is because recompression therapy will subject the diver to an environment of pressure differences that are similar to the pressure changes that may have caused the injury. When divers experience tinnitus or hearing loss with ear barotrauma, it should be taken seriously: A trip to a local ear, nose and throat doctor (an ENT, or

otolaryngologist) is recommended. Treatment for suspected inner ear barotrauma includes:

- Bed rest with the head elevated;
- Avoiding increase of inner ear pressure (e.g., avoid Valsalva maneuvers, blowing the nose, coughing, or bearing down/straining while lifting or defecating);
- Some medications: physicians may suggest oral decongestants if the diver has responded to them in the past, and decongestant nasal sprays/drops can help reduce swelling in the mucous membrane (although they do not work immediately; they are actually better for prevention).

Antibiotic ear drops or ointments are rarely of any value unless an external infection is diagnosed. The eardrops may also be ototoxic (i.e., harmful to the ear) if the wrong antibiotic is given for a tympanic membrane rupture.

Inner ear barotrauma accompanied by progressive hearing loss may require exploratory surgery. Some ENT physicians recommend a period of time to medically monitor the diver to allow for improvement. However, if symptoms worsen or do not improve after 10 days of conservative therapy, surgery may be the prescription.

Test Your Knowledge – answers Question1's answer is B; the answers to question 2 are D & E.

DIVER 2

The Diver

This 35-year-old woman is an open-water student. She is healthy, on no medications and has no significant medical history.

The Dive Profile

The diver and her classmate made open-water certification dives in a quarry. Dive #1 went to a depth of 40 feet (12 meters) for 40 minutes; dive #2 was a five-minute dive to 15 feet (5 meters). The diver reported that she had no problems equalizing during the pool sessions portion of her training, but during the first open-water dive, she felt increased pressure in her ears as she descended. She did eventually equalize both ears, but it took quite a bit of effort. There were no complications during the dive. After the first dive, she reported that her ears felt blocked and that she had the sensation of water in side her left ear. She tried to make a second dive, but, even after repeated attempts, she could not equalize her ears: After she descended to 15 feet (5 meters), she decided to abort the dive. After the dive day, she reported that her ears felt very uncomfortable. Over the next several days, she reported a continuous feeling of fullness, like cotton in her ears, and hearing loss. She does not have any pain. She called DAN for a referral to an ENT physician in her area. er, if symptoms worsen or do not improve after 10 days of conservative therapy, surgery may be the prescription.

Test Your Knowledge

3. *What is the most likely diagnosis?*

A. Middle ear barotrauma
B. Inner ear barotrauma
C. Inner ear decompression sickness

4. *What would be the best treatment?*

A. Hyperbaric oxygen
B. Oral decongestant
C. Bed rest with head elevated
D. Nasal sprays/drops

The Discussion

The most common injury in diving is middle ear barotrauma (MEB), also known as ear squeeze. Its cause? Inadequate equalization of the middle ear air space is one of the typical reasons divers experience MEB. When the external pressure (ambient) is greater than the pressure in the air space of the middle ear, it creates a vacuum. The lack of timely equalization will cause swelling and congestion in the middle ear and Eustachian tube. In this particular diver, the dive profile was benign, so the risk of DCS is small. The diver reported difficulty equalizing, and her symptoms of fullness and hearing loss indicated a squeeze. She denied having vertigo/ dizziness or tinnitus, so the symptoms where probably limited to middle ear barotrauma.

Treatment for suspected middle ear barotrauma may vary with the severity of the symptoms. They can include these recommendations:

- Discontinue diving and equalization attempts until symptoms resolve.
- Use a long-acting nasal decongestant such as oxymetazoline hydrochloride (Afrin(r)) or a systemic decongestant like psuedoephedrine (Sudafed(r)): They may help resolve symptoms more quickly. Due to pseudoephedrine's effects on blood pressure – i.e., it tends to increase it – exercise caution. People with a medical history of diseases such as hypertension, glaucoma, hyperthyroidism or diabetes, should consult with their physician prior to taking any medication like this.
- Use steroids when the severity of the inflammation indicates that need. Your doctor will help you with that decision.
- If your doctor suspects rupture of the tympanic membrane, avoid antibiotic or any type of ear drops. Many antibiotic ear drops are toxic to the inner ear.

Avoiding middle ear barotrauma can be the best treatment. Prevention can include the following: alternative equalization techniques, slowing the descent, avoiding diving with a recent history of sinus congestion or allergies and always avoiding a forceful Valsalva. If divers experience pressure in the ears while descending, they should stop and slowly ascend a few feet until they can equalize gently. If you cannot equalize, you should abort your dive: It's better to wait for clearer passages on another dive day. In addition, most pharmacies offer pediatric nasal decongestant drops available over the counter. Use such drops with a gentle Valsalva; this places the medication directly into the Eustachian tubes. Refer to use instructions for dosage and frequency.

Test Your Knowledge -answers The answer to question 3 is A; question #4 is B.

DIVER 3

The Diver

This 43-year-old man has logged more than 500 dives. Other than a history of controlled hypertension, he is healthy and exercises regularly.

The Dive Profile

The diver was on a weeklong dive trip in the Pacific: All dives were multilevel and within the no-

decompression limit, according to his computer. He made all dives breathing compressed air. On the first day, the diver went to 75 feet (23 meters) for 35 minutes, followed by a two-hour surface interval. On his second dive he descended to 60 feet (18 meters) for 60 minutes, with a two-hour surface interval afterward. His third dive was to 50 feet (15 meters) for 30 minutes. He reported no problems or concerns on any of the dives. The dive profile on Day 2 went to 100 feet (30 meters) for 25 minutes, the day's only dive. Approximately 20 minutes after surfacing, he reported a sudden onset of severe vertigo, nausea, vomiting and tinnitus. These symptoms did not change during the next 30 minutes it took to reach shore. The boat crew could not perform a field neurological evaluation because his vertigo prevented him from standing. After a consultation with DAN, the diver was transported to the nearest medical facility for evaluation.

Test Your Knowledge

5. *What is the most likely diagnosis?*

A. Middle ear barotrauma
B. Inner ear barotrauma
C. Inner ear decompression sickness

6. *What would be the best treatment?*

A. Oxygen first aid in the field
B. Hyperbaric oxygen
C. Decongestant
D. Bed rest with head elevated

The Discussion

Getting an accurate dive profile, symptom onset time and physical evaluation are always important in establishing a diagnosis, especially if inner ear decompression illness is a consideration. In this case, the diver had significant nitrogen exposure – i.e., four dives in two days – even though he was within the nodecompression limits on his computer. He did not report any difficulties equalizing his ears; this helped rule out barotrauma. The symptoms began 20 minutes after he had surfaced. If symptoms begin during or shortly after the decompression portion of the dive, inner ear DCS is a likely diagnosis. Also, the diver's symptoms of vertigo, nausea, vomiting and tinnitus are classic symptoms of inner ear DCI. While the diver with suspected inner ear DCS still needs to have the middle ear evaluated, the primary treatment for inner ear DCI includes immediate oxygen first aid in the field and eventual hyperbaric recompression. As soon as possible after the hyperbaric treatment, physicians need to conduct a complete otoneurological evaluation (a complete exam of the neurological function of the ear). This should include audiometry (a hearing test) and electronystagmography (testing of the acoustic nerve) studies. If there is injury in one ear, the other ear will often compensate. Additionally, within a few weeks the diver may no longer experience symptoms, although this does not necessarily indicate that the inner ear has healed. Such tests will help to determine the extent of the damage.

The recommendation for some divers with permanent damage due to inner ear DCI is not to return to diving. Some physicians may allow a return to diving for individuals who had complete resolution of their symptoms and are unaffected by any type of residual symptom such as vertigo, ataxia (lack of motor coordination) and nystagmus (oscillation of the eyes). This may mean repeating some studies to confirm that the inner ear has sustained no damage.

It is sometimes difficult to differentiate inner ear DCI and inner ear barotrauma. Prompt recompression

therapy is essential for inner ear DCS, but it is not recommended for inner ear barotrauma unless neurological decompression sickness symptoms accompany it. Your best advice is to get definitive medical care as soon as possible.

Test Your Knowledge – answers Question 5 is C; the answers to questions 6 are A & B.

Snapshot of an Ear Injury

The middle ear is a space behind the eardrum that is vented to the atmosphere by the auditory (Eustachian) tube. Because it's connected to the back of the throat, if this tube is blocked – usually it's mucus from a cold or allergy – the space behind the eardrum cannot equilibrate with ambient pressure. If the pressure difference across the eardrum is small, the result may be only a slight injury, usually referred to as a squeeze). Symptoms include a sense of fullness and muffled sound in the affected ear, or there may be frank pain as the eardrum distends.

Large pressure differences can have serious results – rupture of the eardrum and/or damage and rupture of a similar smaller membrane covering the round window inside the ear. If an eardrum ruptures, the pain of eardrum distension is suddenly relieved, but with subsequent problems. If water, particularly cold water, suddenly enters the middle ear, it causes dizziness and possibly severe nausea. Fortunately, symptoms disappear when the temperature difference is resolved – that is, ambient body heat will warm the water in the ear.

The downside to this is a ruptured eardrum and the need for antibiotics to combat subsequent infection. Ear-clearing injuries occur most commonly during diving descent and can result from descending as little as 6 feet (2 meters) or more with a blocked Eustachian tube or from forceful clearing attempts once the ear is blocked. Ear-clearing injuries are rare on ascent because the shape of the Eustachian tube allows gas to exit easily. Applying proper ear-clearing techniques can help prevent most injuries.

Signs & Symptoms

- Nystagmus (rapid back-and-forth
- Nausea eye movement)
- Ear pain
- Hearing loss
- Loss of balance
- Traumatic eardrum damage
- Jaw or neck pain
- Dizziness
- Hearing difficulty

About the Author

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