Sandrine's notes - with thanks to Peter Mosse for his review



What does the term "barotrauma" (BT) mean?

Ancient Greek words : Baros, barys = weight. Trauma = wound.

BT simply means pressure injury.

- Descent BT = squeeze injury i.e. reduced volume and tissue "swelling " (pain) and blood has to fill the space.
- Ascent BT = reverse squeeze i.e. expanded air space, increased tissue pressure on nerves etc.

What is the relationship between pressure and volume (Boyles Law)?

It's almost a constant: Pressure x Vol = almost a constant, as long as the temperature remains the same.

All air spaces are subject to this law. So, what happens during descent and what happens during ascent?

During descent

Pressure augments by 1 Bar every 10m. Typically being 1 Bar at the surface (weight of a 1cm2 column of air). Then each 1cm2 column of 10m water = 1 Bar

List the main types of descent barotrauma + signs and symptoms of each of these.

Ear

From https://mdaskme.com/blog/2024/06/24/ear-pressure-problems-navigating-eustachian-tube-dysfunctionP



Ear squeeze can occur in the ear canal or middle ear.

Pain, that leads to the actual rupture of the tympanic membrane (TM) may occur and usually occurs in divers with Eustachian tube dysfunction. On the descent, as pressure builds up between the ear canal, TM, and the nasopharynx, the Eustachian tube should function to equalize this. If not, pain will ensue, TM may haemorrhage or rupture. Curiously this is heralded by a sudden decrease in pain. However, hearing loss, whirling vertigo, tinnitus, and bloody drainage may ensue.

Occasionally the pressure gradients across the left and right TMs differ asymmetrically, usually due to eustachian tube mismatch, alternobaric vertigo may occur. This may present with disorientation, nausea, vomiting, vertigo, and tinnitus. Drownings have occurred due to disorientation or vomiting.

Sinuses

From https://navage.com/pages/will-this-help-rinse-my-sinuses



Sinus squeeze can be excruciating. Bloody nasal discharge is seen. Sinuses are truly closed spaces, except for the functioning of their ostia, the natural openings or passages in the sinuses that allow for ventilation and drainage between the sinuses and nasal cavity. These openings are crucial for equalizing pressure in the sinuses during diving.

Sinus squeeze usually occurs in divers with some degree of chronic sinusitis, allergies, mucoperiosteal thickening, nasal polyps, and ostial occlusion.

Teeth

Dental pain is caused by pressure effects at the site of fillings, apical abscesses, or carious teeth. Fillings may distort. And carious teeth may implode on the descent.

Air spaces can develop underneath defective fillings. This results in a squeeze that's impossible to equalize during descent. Dental squeeze can cause an implosion of carious teeth.

If you feel pressure in a tooth while diving, **abort the dive** and make an appointment to see a dentist.

If you ignore a tooth squeeze, the pressure may slowly equalize. This will cause a reverse block during ascent, and result in a loose filling or fractured tooth.

What to do if pain after diving?

1. Seek Dental Care:

- **Tooth squeeze:** This is a common diving-related dental problem where air trapped in a cavity
- Other dental issues: Diving can also exacerbate pre-existing dental problems or cause new ones.
- **Don't delay:** Early treatment can prevent further damage and pain.

2. Temporary Relief:

- **Cold Compress:** Apply a cold compress (ice pack wrapped in a towel) to the outside of your cheek near the painful tooth for 15 minutes at a time, followed by 15 minutes off, to reduce swelling and numb the area.
- **Over-the-counter pain relievers:** Take ibuprofen (Advil, Motrin) or acetaminophen (Tylenol) as directed on the label for pain relief.
- Avoid hot or cold foods and drinks: These can exacerbate the pain.
- Eat soft foods: This can help reduce the pressure on your teeth and gums.
- 3. Preventative Measures for Future Dives:
- **Regular dental checkups:** Ensure your teeth and gums are in good condition before diving.
- Address any dental issues: Get any cavities, fillings, or other problems treated before diving.
- **Be mindful of your mouthpiece:** Make sure your mouthpiece fits comfortably and doesn't cause excessive pressure on your teeth.
- Relax your jaw: Avoid clenching your teeth tightly on the mouthpiece.
- Avoid diving for a few days after dental work: Allow your mouth time to heal after dental procedures

Mask squeeze

Occurs when a diver fails to equalize the air space in their mask during descent, resulting in damage to the blood vessels and soft tissues of the eyes and face.

From https://www.ncbi.nlm.nih.gov/books/NBK545224/

The vast majority of mask squeeze injuries require no treatment. Mild injuries to the skin, including swelling, bruising, petechia, will resolve within one to two weeks with supportive care. Mild eye injuries, including conjunctivitis and subconjunctival hemorrhages, will also resolve without any intervention in a short time. More severe eye injuries such as a subperiosteal orbital hematoma require emergent evaluation by ophthalmology. If this injury involves compression of the optic nerve or evidence of increased intraocular pressure, needle aspiration or orbitotomy with drainage may be required. Otherwise, conservative management of the eye injury with follow-up visits with ophthalmology may be all that is required.

How can you as a diver avoid descent barotrauma?

Before descent:

- Do not dive with congestion or a cold when there is already a buildup of fluid in the throat and eardrums. Congestion causes a shrinking in the tubes, which makes it harder to force in air and equalize pressure.
- Refrain from diving when feeling popping or crackling in your ears, or if you have a feeling of fullness in your ears after diving.
- Breathe fresh, clean air before descending into the water. Since the eustachian tube connects the eardrum to the throat, and ultimately the respiratory system, avoiding irritants such as boat fumes and cigarette smoke will help divers avoid inflammation and pain.

Drink lots of water to thin mucus so that it doesn't clump and block the eustachian tube.

- Avoid dairy products for two days before a dive as it can contribute to thick mucus.
- Use a nasal rinse or neti pot.
- Take caution when using over-the-counter nasal sprays. Repeated use can cause a rebound reaction resulting in increased congestion and a **possible** reverse block on the ascent as their effect can wear off during the dive

 <u>https://photos.app.goo.gl/q2yMxNdsmbFMND1V9</u> - with permission, from Eduard Pudel - Brighton ENT & Specialist Centre

While descending:

From https://dan.org/health-medicine/health-resources/diseases-conditions/middle-ear-equalization/)

Techniques

When properly employed, the following equalization techniques are effective in middle-ear and sinus equalization in healthy divers.

- Passive: Requires no effort; occurs during ascent
- Voluntary Tubal Opening: Yawn or wiggle your jaw
- Valsalva Maneuver: Pinch your nostrils and gently exhale through your nose
- **Toynbee Maneuver:** Pinch your nostrils and swallow (useful for equalizing during ascent)
- **Frenzel Maneuver:** Pinch your nostrils while contracting your throat muscles and make the sound of the letter *K*
- **Lowry Technique:** Pinch your nostrils and gently try to exhale through the nose while swallowing (a combination of the Valsalva and Toynbee maneuvers)
- Edmonds Technique: Push your jaw forward and do the Valsalva or Frenzel maneuver

Tips for Equalization

- Before descent, while you are neutrally buoyant with no air in your BCD, gently employ one of the listed techniques to add air to your middle ears and sinuses as you descend.
- Descend vertically, feet first, to allow air to travel naturally upward into the Eustachian tube and middle ear. Use a descent line or the anchor line to control your speed.
- Gently inflate your ears every few feet for the first 10 to 15 feet.
- Pain is not acceptable. If you have pain, you have descended without adequately equalizing. Ascend a few feet until the pain stops.
- If you do not feel your ears equalizing, stop descending and try again. You may need to ascend a few feet to reduce the ambient pressure. Do not bounce up and down.
- It may be helpful to tilt your blocked ear toward the surface.

- If you are unable to equalize, abort the dive. The consequences of descending without equalizing could ruin an entire dive trip or cause permanent damage or hearing loss.
- If at any time during the dive you experience pain, vertigo or sudden hearing loss, abort the dive. If these symptoms persist, do not dive again and consult your physician.

Why is over forceful equalisation risky?

Pushing air through too often can stretch the eardrum, damage to the inner ear and the eustachian tube, causing pain as well as making it even harder to equalize with each dive. Can result in progressive loss of hearing

Ascent BT

- The obvious one: the lungs
- Sinuses and teeth fillings expand, root abscesses expand, pain.
- But also gut squeeze. It can be very uncomfortable and worrying to some divers.

Further discussions

- On a multi-day dive trip, many divers experience some tenderness in their ears and increasing difficulty equalising.
 - 1. What is happening?
 - 2. What is the risk if they continue to dive and it gets worse?
- What is Alternobaric Vertigo?

What is it: A condition that occurs during diving when uneven pressure equalization between the left and right ears creates a pressure differential

Symptoms: disorientation, nausea, vomiting, vertigo, and tinnitus

This potentially dangerous condition can lead to drowning due to disorientation or vomiting underwater.

Other references

- From John Lippmann and Co:
 - <u>https://adsf.cdn.prismic.io/adsf/de1febe4-15db-49bf-931e-</u>
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