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DIVING MEDICINE

THE MIDDLE EAR UNDER PRESSURE

+ I ONCE MET A DIVER WHO HAD DEVELOPED TERRIBLE DIFFICULTY IN 'CLEARING' HIS EARS DURING DIVING. SUCH WAS HIS MISGUIDED DEVOTION TO THE SPORT THAT HE SUGGESTED THAT I SIMPLY FILL HIS EARS WITH CONCRETE RATHER THAN LET THE PROBLEM INTERRUPT HIS WEEKLY DIVING EXCURSIONS. MOST OF US ARE MORE PRAGMATIC THAN THAT AND RECOGNISE THE NEED TO TREAT OUR EARS WITH CARE. INDEED, THE MOST COMMON MEDICAL COMPLAINTS ARISING FROM DIVING ARE THOSE INVOLVING THE EARS. SOME OF THESE EAR PROBLEMS ARE POTENTIALLY SERIOUS.

Divers are most vulnerable to ear problems early in their careers, and especially during training. It follows that the diving Instructor must take the issue of teaching "ear care" during diving very seriously. This article discusses the mechanism of hearing and several pressure-related ear problems. It will also provide some practical advice for any diver having difficulty in equalising pressure in their ears, and particularly for Instructors to pass on to trainees.

STRUCTURE OF THE EAR

First, a little of the basic anatomy and physiology of hearing. We think of the ear as being divided into three parts: the outer, middle and inner ear. The outer ear is essentially the pinna (that floppy appendage on the side of your head) and the hole leading into the eardrum. This part of the ear collects sound and channels it to the eardrum. The sound causes the eardrum to vibrate.

The middle ear is an air-filled cavity in the skull, sealed off from the external environment by the eardrum. The cavity is lined by a thin layer of tissue called mucosa, and is linked to the throat behind the nose by the eustachian tube. A chain of three small bones (the "ossicles") are found in the middle ear. These link the eardrum to a small membrane (the "oval window") behind which, deeper in the skull, lies the fluid of the inner ear. Vibrations of the eardrum are transmitted by the ossicles to the oval window, setting up vibrations in the inner ear fluid.

The inner ear is a complex organ in the form of a fluid filled tube (the "cochlea") with the oval and round windows (flexible membranes) sealing either end. Vibrations caused by the ossicles acting on the oval window are transmitted through the fluid to the other end of the tube where the second membrane (the round window) vibrates in sympathy. Throughout the length of this tube is a sensory structure that transduces the vibrations to nerve signals that are interpreted by the brain as sound. A complex array of small fluid-filled sacks and tubes (the "semicircular canals") lie in association with the inner ear, and are involved in sensing head position and movement, and in maintaining balance.

PRESSURE DAMAGE TO THE MIDDLE EAR

Of the three parts, the middle ear is most affected when diving, simply because it is an air space. On descent, the pressure surrounding the diver increases and the pressure outside the middle ear will rapidly become greater than inside.

Unless steps are taken to equalise these pressures, damage to the middle ear may occur in two

ways. Firstly, the eardrum bows inwards and may ultimately rupture if the pressure differential becomes too great.

Secondly, the soft tissue mucosa that lines the middle ear swells up with blood and fluid in an "attempt" to fill the middle ear space. If the pressure differential is severe enough, the mucosa may actually bleed and fill the middle ear cavity with blood. These processes

are commonly referred to as "ear squeeze" but are more correctly called "middle ear barotrauma".

As these events occur, the diver will experience ear pain increasing with depth. If the eardrum bursts, the pain may abate, but the sudden rush of cold water into the middle ear can cause dangerous but transient vertigo. A diver with a ruptured eardrum may continue to experience pain after the dive and is likely to notice partial deafness in the affected ear. If the eardrum remains intact but there is bleeding into the middle ear, the ear may remain painful after the dive and there will be a sensation of "fullness" and deafness in the ear.

PREVENTION OF MIDDLE EAR PRESSURE DAMAGE

Of course, all this can be avoided if one equalises the middle ear pressure to that of the surrounding sea as depth increases. This is usually achieved by the valsalva manoeuvre, in which the diver generates positive pressure in the upper airway against a pinched nose. This forces air up through the normally closed eustachian tube into the middle ear. Some divers can achieve this by simply swallowing or wiggling their jaw. If pressure in the middle ear is allowed to become significantly negative relative to the surrounding pressure, then the eustachian tube collapses and no equalisation technique will work. This is the reason for the advice to "equalise early and often".

The most common causes of an isolated episode of difficulty equalising pressure are starting equalisation too late, or acute inflammation of the upper respiratory tract caused by colds, flu, hay fever etc. In the latter case, the eustachian tube becomes blocked by inflammation in its wall, and/or excessive mucus production. It is dangerous to dive with any of these conditions because of the possibility of ear damage. The use of decongestants to allow diving in the presence of acute inflammation, especially from an infective cause, is not recommended.

Some divers have chronic difficulty equalising pressure even having been taught properly and being in good health. The reason is often difficult to determine. There are a variety of possibilities, such as chronic inflammation; anatomical defects in the nose, eustachian tube, or upper airway behind the nose; or enlarged adenoids. Divers with such problems should seek advice from a specialist otolaryngologist. Sometimes these problems can be corrected or at least improved. People with chronic and total inability to equalise should not be diving.

Those who are able to equalise, but have more difficulty than most need to be particularly cautious with their ears. Novices must be targeted by instructors for intense education in ear care while diving (see below).

EAR CARE ADVICE

THE FOLLOWING ADVICE IS RELEVANT TO ALL DIVERS, BUT IS ESPECIALLY IMPORTANT FOR THOSE WITH SOME EQUALISING DIFFICULTY.

1 There should be a low threshold for cancellation. If the ears don't feel normal or there is any increased congestion on the day, diving should be cancelled.

2 Dive with a buddy who will not be intolerant of slow descents. Pressure from buddies is dangerous in this situation.

3 Descent technique:

a) Control is essential, eg anchor line or cliff face with weed to hang on to. Divers with difficulty clearing the ears should not perform free descents unless they have very advanced buoyancy control skills.

b) Descent in the head up position. Most divers find that pressure equalisation is easiest in the upright position. In addition, the diver is in the best position to slow the ascent by finning if ear problems occur.

c) Proceed slowly.

d) The commonly taught practice of responding to any ear pain by ascending until pain disappears and then attempting to descend again with attention to the points below is good technique.

4 Equalisation technique:

a) Grip the nose and blow gently (the 'Valsalva manoeuvre'). This manoeuvre should begin before initiation of the descent and be constantly maintained during descent, especially in the first 10 metres. Thus, the diver's nose grip should not be broken during this time. Divers must not wait for ear pain to remind them that equalisation is required.

b) Wiggling the jaw, jutting it forward and swallowing are all useful adjuncts to the Valsalva manoeuvre, as they tend to promote opening of the eustachian tube.

c) Avoid overly-forceful Valsalva manoeuvres.

'REVERSE SQUEEZE' - A SPECIAL CASE

Air introduced to the middle ear at depth to equalise pressure will



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expand on ascent, but usually bleeds back out of the eustachian tube automatically without conscious effort. If this fails to occur – that is, the eustachian tube becomes blocked at depth once equalisation has occurred – the expanding air cannot escape the middle ear cavity. In this case the pressure in the middle ear will become greater than the surrounding pressure during ascent, and we speak of ‘reverse squeeze’ or ‘reverse block’. The diver experiences increasing ear pain during ascent, and if unrelieved, the eardrum may rupture outward. Attempts to valsalva should not be made to relieve this pain. A slow stepwise ascent with lots of swallowing and jaw wiggling to try to open the eustachian tube is the best advice. It may be necessary to remove the regulator to do this.

THE APPROPRIATE RESPONSE TO EAR SYMPTOMS AFTER DIVING

It is common for divers, especially trainees, to report at the post dive debrief that they had “a little ear pain during descent”. Divers who experienced difficulty with their ears during a dive should receive careful counselling about middle ear equalisation before diving again. They should not perform another dive if they have ongoing ear symptoms such as pain, a feeling of fullness, or decreased hearing. Indeed, under these circumstances a senior diver or instructor should strongly recommend review by a physician (see below). Nor should diving take place if the valsalva manoeuvre (or equivalent) cannot be easily performed. Diving can be resumed by divers who experienced ear pain on a recent dive, provided they: have

no ongoing symptoms (and never did have dizziness or hearing loss); have been counselled about equalisation techniques; and can easily feel both ears “pop” using the Valsalva manoeuvre.

Any case in which symptoms of middle ear barotrauma persist for more than a few hours after a dive deserves review by a physician. If the symptoms include dizziness, significant hearing loss, or ringing in the ears then this should be considered both mandatory and urgent because these symptoms are virtually never due to benign causes and may require early treatment. In most cases the treatment of any problem will be conservative. Even ruptured eardrums are usually left to heal themselves, and blood or fluid in the middle ear is almost always left alone to drain or reabsorb by itself. Doctors vary in their approach to this, but some will prescribe decongestants to hasten drainage of the middle ear. In cases of eardrum rupture, some will prescribe a course of antibiotics to guard against bacterial contamination of the middle ear although many consider this unnecessary. If the eardrum has ruptured, then diving should not resume until a physician has confirmed that it has healed. This usually takes four to six weeks. In less serious cases (no rupture) diving can resume after all symptoms have settled and the diver can Valsalva normally (see below).

THE FINAL WORD

Ear problems are common in diving, especially early in the diver’s career. With a combination of good teaching and practice, most divers eventually master the skills necessary to protect their ears. The instructor has a key role to play in this process. ■