

Ruptured tympanic membrane from underwater impact with an Atlantic salmon, *Salmo salar*

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Key words

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Abstract

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An unusual case of tympanic membrane rupture in a diver due to impact from an Atlantic Salmon, *salmo salar* is described. The diver was treated conservatively and the injury fully healed by eight weeks after which the diver successfully returned to diving. The author contends that the appearances of such traumatic perforations differ from barotrauma in divers secondary to ear clearing problems on descent.

Introduction

Ear barotrauma is a common injury in compressed gas divers and snorkellers. Middle ear barotrauma (MEBt) is a subset of ear barotrauma and is the most common medical disorder experienced by divers, constituting 46% of diving ear, nose and throat disorders.^{1,2} It results from inability to auto-inflate the middle ear to match the outside pressure as it rises when the diver descends. The tympanic membrane (TM) is stretched beyond physiological limits sustaining injury. The MEBt injury presents as a spectrum from symptoms of blockage (but no signs), through progressively increasing inflammation in the middle ear and of the TM, which frequently is accompanied by an effusion.¹

The most extreme form of MEBt is a perforation of the TM. Exact figures are unknown, but perforated TM is quite rare in divers compared with other grades of MEBt, probably because they experience intolerable pain and abort their dive before perforation occurs. In addition, effusion and middle ear mucosal swelling may dampen the degree of force on the TM, protecting it from the extreme deviation that produces perforation. If a perforation does occur in this setting, it may be subtle and difficult to diagnose. Divers exposed to a rapid descent (for example, accidental over-weighting) or a sudden external pressure force (for example, a blast injury) may also present with TM perforation. Three cases have been reported anecdotally from swim fin blows to the side of the head, despite water-polo cap ear protection, during underwater hockey competition (Davis FM, personal communication, 2017). It is believed this is the first reported case of TM rupture due to direct impact from the Atlantic salmon, *Salmo salar* (presented with the patient's permission).

Case report

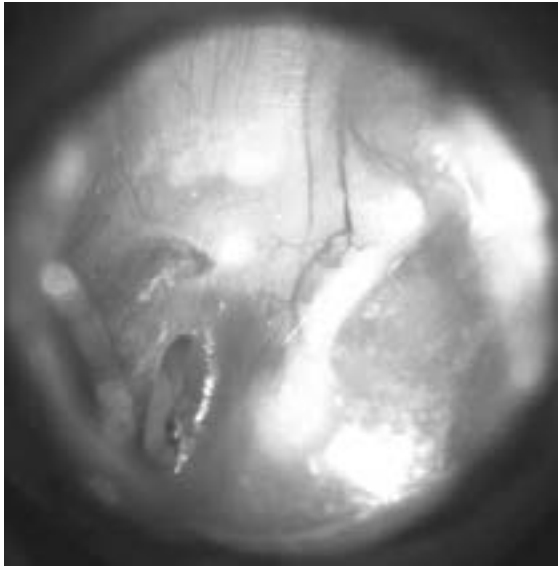
A 34-year-old male occupational diver was undertaking his usual duties as a diver on an Atlantic salmon farm in Tasmania, Australia. He was wearing an 8 mm wetsuit with full neoprene hood, breathing from surface supply breathing apparatus with communications. He had completed a number of dives within the salmon pens as part of his routine work. He had no ear clearing problems or symptoms during his dives. He was submerged at a depth of 17 metres at the base of the fish enclosure when he noticed that the salmon were unusually active and swimming rapidly around him. A fish of approximately 5 kg in mass collided with the right side of his head over his right ear, causing him immediate pain, tinnitus and a brief feeling of vertigo. He communicated the event to his supervisor then commenced a slow ascent.

On arrival at the support vessel, his vertigo had improved, but he had persistent pain, tinnitus and impaired hearing in the right ear. He was initially assessed by his local GP, who referred him to the Royal Hobart Hospital hyperbaric facility. Otoscopic examination demonstrated a normal left tympanic membrane (TM), with normal auto-inflation. The right TM demonstrated a small (< 25%) perforation in the lower *pars tensa* (Figure 1). The otoscope fogged when a Valsalva manoeuvre was attempted, and tympanometry persistently recorded 'open' without producing a pressure curve. Audiometry demonstrated minor loss (10 dB) in high frequencies compared to his last fitness-to-dive assessment.

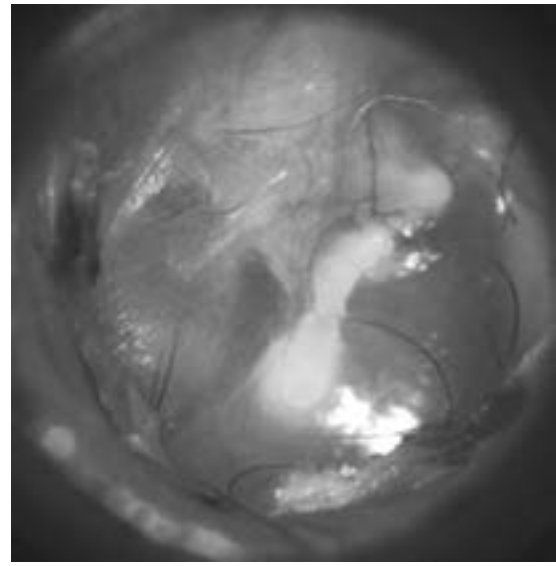
The diver was treated conservatively with analgesia and advised not to dive for eight weeks and to keep the ear dry. During this period, he undertook surface-based activities for his employer. Eight weeks later, he was asymptomatic with

Figure 1

Right tympanic membrane showing perforation in the *pars tensa*

**Figure 2**

Healed right tympanic membrane at eight weeks post injury



normal looking TMs bilaterally (Figure 2). Autoinflation, tympanometry and audiometry were normal. He has successfully returned to diving without problems.

Discussion

Traumatic TM rupture can cause severe pain, bleeding, tinnitus and hearing loss for the injured individual.¹⁻³ Other than diving, TM perforation can result from multiple aetiologies. These can include direct penetrating trauma from foreign objects, percussion injury (slaps, water ski accidents), sudden negative pressure, basal skull fracture, barotrauma or iatrogenic injury.^{3,4} Larger perforations appear to result from higher energy injuries or direct penetrating trauma. The following factors affect prognosis for healing: large perforations are less likely to heal spontaneously; final healing and hearing results are good regardless of treatment employed; spontaneous healing provides a better result than surgical intervention and infection adversely affects healing.⁴ “*Masterly inactivity should be religiously followed and unnecessary surgical intervention should be discouraged*” when assessing treatment options.³ Between 80% and 90% of perforations heal spontaneously inside three months.⁴⁻⁶ Use of gel-foam patches to treat larger tears has been reported to improve healing in a randomised controlled trial.⁶

In my experience of more than twenty cases of perforated TMs from diving, the localised pattern of perforation from *Salmo salar* differs from TM injury sustained by divers when they cannot clear their middle ear, resulting in MEBt. Divers with ear-clearing problems tend to have more widespread injection of the TM associated with the perforation. The perforation is usually less obvious (often a small slit), or may be hidden by haemorrhage, and requires confirmation

by tympanometry. I postulate that this latter injury is due to slower onset of the barotrauma, which may follow multiple (unsuccessful) attempts at clearing the ears. I have been unable to locate any reported cases of tympanic membrane rupture due to direct impact from the Atlantic Salmon, *Salmo salar*, or other fish.

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