Embolic inner ear decompression illness

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Introduction:

Inner ear decompression illness (IEDCI) is thought to be a rare phenomenon in recreational divers, isolated signs and symptoms of inner ear dysfunction usually being attributed to inner ear barotrauma (IEB). A right-to left shunt has been described before as a risk factor to develop decompression illness. The correlation between a right-to-left shunt and IEDCI was first described by our workgroup in 2001. We reported a case of a diver who suffered two episodes of IEDCI who responded well to HBO treatment. In this diver we found a right-to-left shunt of high hemodynamic relevance[1]. This year Cantais et al.[2] presented 34 divers with IEDCI of 101 divers who have been treated for DCI. 24 of the 34 divers (70 %) had a right-to-left shunt whereas only 25 of 101 divers in the control group had a right-to left shunt ($p<0.001$).

Methods and Findings

In the last six years we examined 9 divers with 11 episodes of IEDCI. Every diver but one performed at least 6 air dives before the accident dive. One diver performed a trimix dive to 55 meters of 65 minutes duration. All dives lasted at least 29 minutes and the minimum diving depth was 25 meters. Symptoms occurred in 9 episodes after 15 – 30 minutes. One diver developed symptoms while passing a mountain and one diver developed vertigo and hearing loss while taking a hot shower.
We screened the divers by transcranial doppler sonography and found a right-to-left shunt of high hemodynamic relevance in all 9 divers. Eight divers showed a shunt with more than 99 bubble signals at rest and one diver had more than 50 bubble signals after Valslava manoeuvre. The probability of this group of nine divers all having a right-to-left shunt of high haemodynamic significance is about 0.15[9] (0,00000004) and therefore the association between a right-to-left shunt and presumed IEDCI appears to be highly significant.

Conclusion

The Institute of Naval Medicine/British Hyperbaric Association dive accident database shows that 71 (10.4%) of the 681 divers treated for neurological DCI in the 6 years 1995-2000 reported vestibular dysfunction. Germonpre has estimated that 25 – 30 percent of all divers with neurological symptoms treated at the naval hospital in Belgium have suffered IEDCI (personal communication).
There have been several reports about IEDCI in the last years and in addition to these we examined 9 divers with 11 episodes of IEDCI. Therefore we think that inner ear decompression illness seems not to be a rare disease in divers.
A correlation of a right-to-left shunt and IEDCI is highly significant in our data as well as in the report from Cantais et al.. The German Diving and Hyperbaric Society (GTÜM) recommends that divers with an episode of neurologic DCI in combination with a right-to-left shunt of high hemodynamic relevance are not fit to dive[3]. For this reason every diver with IEDCI should be screened for a right-to-left shunt to prevent him from further damage.

1 Klingmann C, Knauth M, Ries S, Kern R, Tasman AJ. Recurrent inner ear decompression sickness associated with a patent foramen ovale. Arch Otolaryngol Head Neck Surg 2002;128(5):586-8.
2 Cantais E, Louge P, Suppini A, Foster PP, Palmier B. Right-to-left shunt and risk of decompression illness with cochleovestibular and cerebral symptoms in divers: case control study in 101 consecutive dive accidents. Crit Care Med 2003;31(1):84-8.
3 Tauchtauglichkeit Manual. Wendling, Ehm, Ehrsam, knessl, Nussberger (Eds.). 2nd Edition, Biel 2001

	symptoms	max. depth/ max. time	number of repetitive dives	initial hearing loss	max. hearing loss after treatment	treatment/ time delay	persisting symptoms	comments
case 1	tinnitus, vertigo	32 meter/ 50 minutes	9	no initial hearing test	none	none	tinnitus	symptoms occurred after passing a mountain (2 h later)
case 2	vertigo	29 meter/ 60 minutes	20	no initial hearing test	none	HBO/ 3.5 hours	central compensation	
case 3	tinnitus, vertigo	25 meter/ 58 minutes	8	no initial hearing test	none	oral steroids/ 24 hours	tinnitus/ central compensation	
case 4	hearing loss, tinnitus, vertigo	29 meter/ 48 minutes	7	no initial hearing test	no hearing test performed	none	tinnitus	case 4 and 5 same diver
case 5	hearing loss, tinnitus	32 meter/ 29 minutes	10	no initial hearing test	25 dB right side 35 dB left side	100% O_2/ 15 minutes	tinnitus 10 dB hearing loss	See above
case 6	hearing loss	32 meter/ 35 minutes	7	30 dB	0 dB	HBO/ 24 hours	none	case 6 and 7 same diver
case 7	hearing loss, tinnitus, vertigo	50 meter/ 65 minutes	10	35 dB	10 dB	HBO/ 90 minutes	10 dB hearing loss	See above
case 8	vertigo	25 meter/ 60 minutes	7	none	none	HBO/ 24 hours	central compensation	symptoms occurred under a hot shower (2h later)
case 9	hearing loss, tinnitus, vertigo	38 meter/ 58 minutes	12	deaf	80 dB pancochlear	surgery	80 dB hearing loss	
case 10	vertigo	25 meter/ 48 minutes	8	none	none	HBO/ 3.5 hours	central compensation	
case 11	hearing loss, tinnitus, vertigo	55 meter/ 60 minutes	0	50 dB	30 dB	HBO/ 3 hours	30 dB hearing loss	Trimix as breathing gas

Table 1: All symptoms occurred during the first 30 minutes and not immediate after the dive apart from case 1 and 8 (see comments). Two divers experienced two episodes each (Case 4 & 5) and (Case 6 & 8). The divers with HBO treatment reported faster restitution of vertigo but a central compensation was noted in all cases. Divers that suffered hearing loss responded well to HBOT (hyperbaric oxygen treatment). In only 6 of 11 cases the correct treatment was applied. Case 8 had a delay of 7 days until she reached our hospital and could be treated by HBO. Therefore only five of eleven cases had the proper treatment regime!

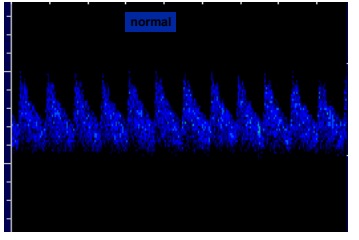

Image 1: Doppler sonographic imaging of the middle cerebral artery. Normal flow without bubble detectiom

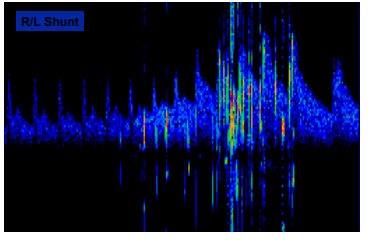

Image 2: Doppler sonographic imaging of the middle cerebral artery. Multiple bubble signals after injection of Echovist® at rest: right-to-left Shunt of high hemodynamic relevance.