Aura after diving
- a case report -

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PMH

- 33 yrs old, male Caucasian
- Senior registrar anesthesiology
- Migraine:
  - with aura from eight yrs of age
  - stopped taking medication yrs ago (didn't help)
  - aura starts in the right temp lower half and expands in 20-40 in after which the headache starts
- PMH: no smoking, no allergies, occ alcohol

Diving history

- started diving in 2000, 300 dives
- 70 tec dives
- diving occasionally triggered his migraine in the past
- A trimix dive triggers an aura without headache in 50% of his dives (post dive)
- no DCI in the past
- The diver was concerned about a possible PFO
- went to an cardiologist who did a TTE without bubble contrast

Nov 2013

- Normoxic Tx CCR course Sharm Egypt
- Nov 16: dive 1 skills, air
- Nov 17: dive 2 skills, air
- Nov 18: dive 3 went according to plan
  - 62 min @ 48 msw
  - Dil: Tx 17/37
  - gradient factors 15/85
  - post dive straining!: CCR + 2 x 10 L cylinders were carried back by diver

No problems equalizing, not tired, voided non-concentrated, urine, comfortable water temp (Red Sea)

60‘ post surfacing

- Aura started and he had to lie down
- When he woke up there was a severe vertigo + dizziness
- nystagmus (fast phase to the left)
- He was put on 100% O_2 and transported to the chamber

@ Adels chamber

- No tinnitus or deafness
- No joints pains
- No skin signs
- No paralysis
- No incontinence
- But severe nausea & vomiting,
- and disturbed equilibrium

Table 6, 5, 5 on subsequent days

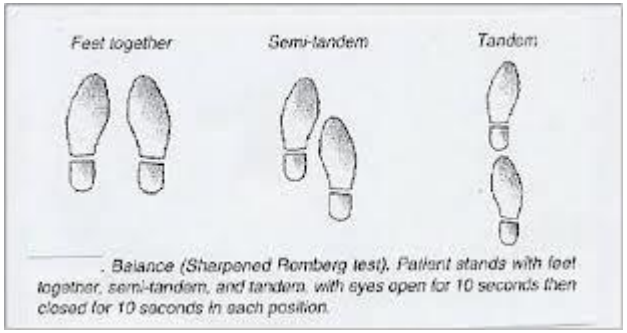
- After 3 recompression sessions:
- No more vertigo, vomiting & nausea
- Residual disturbed gait with a positive Romberg
- Flew back and landed in the UK Nov 26 2013
- Contacted London Hyperbaric Medicine unit for advice.

@ LHM 9 days after incident

- day 9 after incident
- tired, unfocussed, a bit slow
- slightly unsteady gait
- sharpened Romberg 4 sec
- neuro exam: nil of note
- no hearing loss (subj)

Sharpened Romberg

Truncal stability:
- vision
- proprioception
- vestibulur sense



. Balance (Sharpened Romberg test). Patient stands with feet together, semi-tandem, and tandem, with eyes open for 10 seconds then closed for 10 seconds in each position.

- no shoes
- eyes closed
- arms folded

Positive if unfolding arms or opening eyes < 30-60 sec

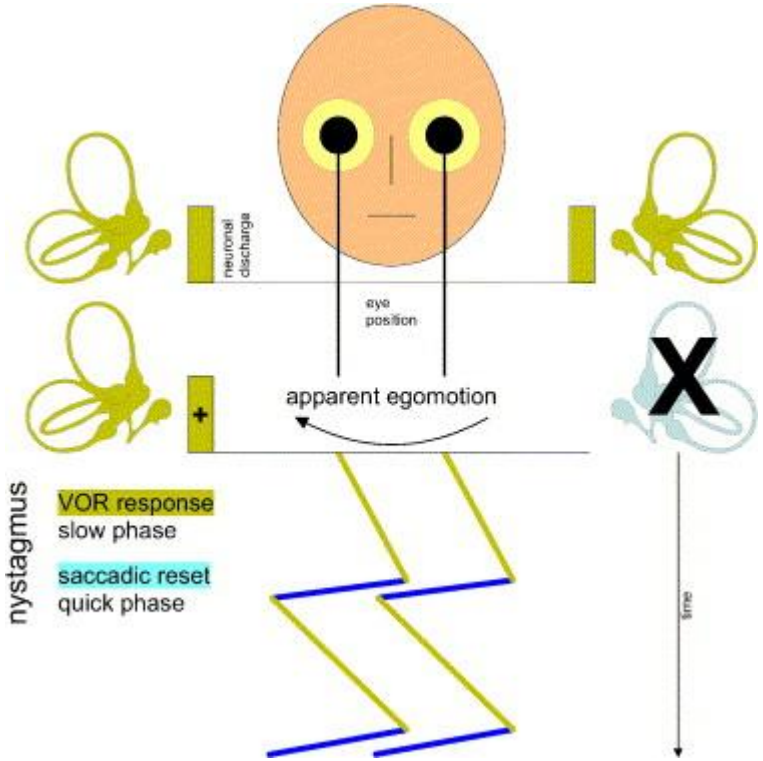
Cut of point 40 sec:
- sensitivity 40%
- specificity 95%

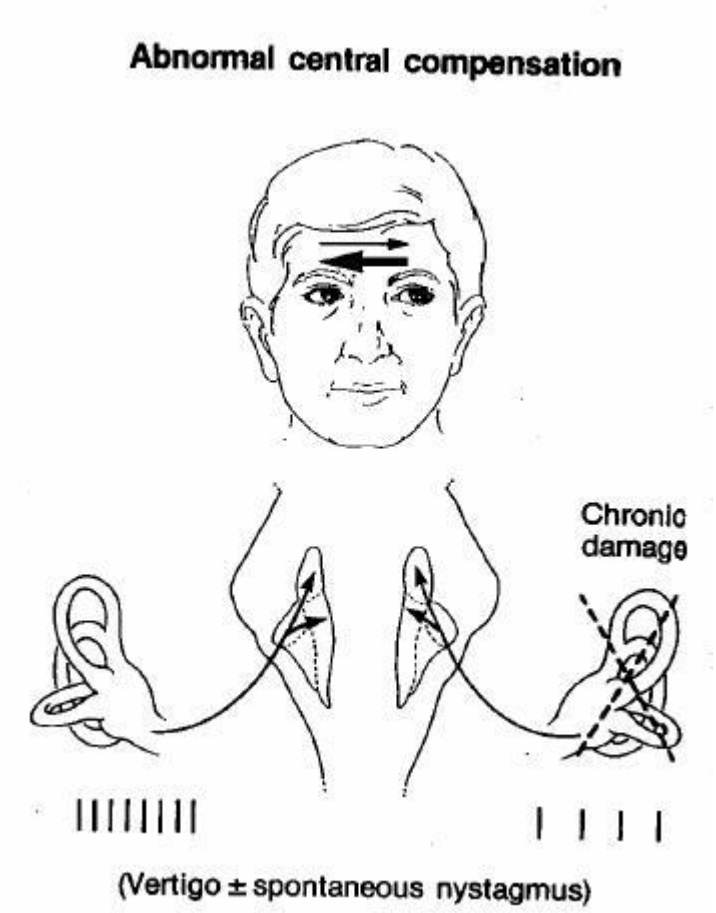
Lee CT. Sharpening the sharpened Romberg. SPUMS 1998;28:125-32

Vestibular origin

- vertigo, nystagmus, nausea/vomit and + Romberg
- fast phase to the left suggests an affected right sided labyrinth.
- DD pos Romberg:
  - cerebellar location: unlikely, no tremor and no severe coordination disturbances
  - cord lesion: unlikely, no other signs

Nystagmus


neuronal discharge
eye position
apparent egomotion
+
X
nystagmus
VOR response
slow phase
saccadic reset
quick phase
time


Abnormal central compensation
Chronic damage
(Vertigo ± spontaneous nystagmus)

DD vestibular symptoms

- migraine associated vertigo
  - prevalence 1% of population
  - symptoms may last for days..but 9 days???
- round window rupture
  - unlikely: symptom free interval and no equalizing problems
- AGE
  - unlikely due to symptom free interval and normal ascent
- other medical: young fit male.... unlikely
- Inner Ear Decompression Sickness (IEDCS)
  - responded to recompression!

Cal R, bahmad F. Migraine associated with auditory-vestibular dysfunction. Brazillian Journal of Otorhinolaryngology 2008;74:606-12
Lempert T. Epidemiology of vertigo, migraine and vestibular migraine. J neurol. 2009;256:333-8

IEDCS

- Inner Ear Decompression Sickness
- targets the labyrinth and cochlea
- **vertigo! 95%**
- unsteadiness
- dizzyness
- hearing loss 40%
- tinnitus 44%

Isolated IEDCS in approx 50% of cases of IEDCS
Why?

Nachum Z, et al. Inner ear decompression sickness in sport compressed-air diving. Laryngoscope 2001;111:851-856

Klingmann c, et al. Barotrauma and decompression ilness of the inner ear: 46 cases during treatment and follow up. Otol Neurotol 2007;28:447-54

? Isobaric counter diffusion

- decompression diving: isobaric switch from He rich to a N_2 rich mixture (gas switch)
- N_2 flow into membranous compartment exceeds He washout (despite He being a faster gas)
- transient **supersaturation** of membranous = vascular compartment → bubble formation

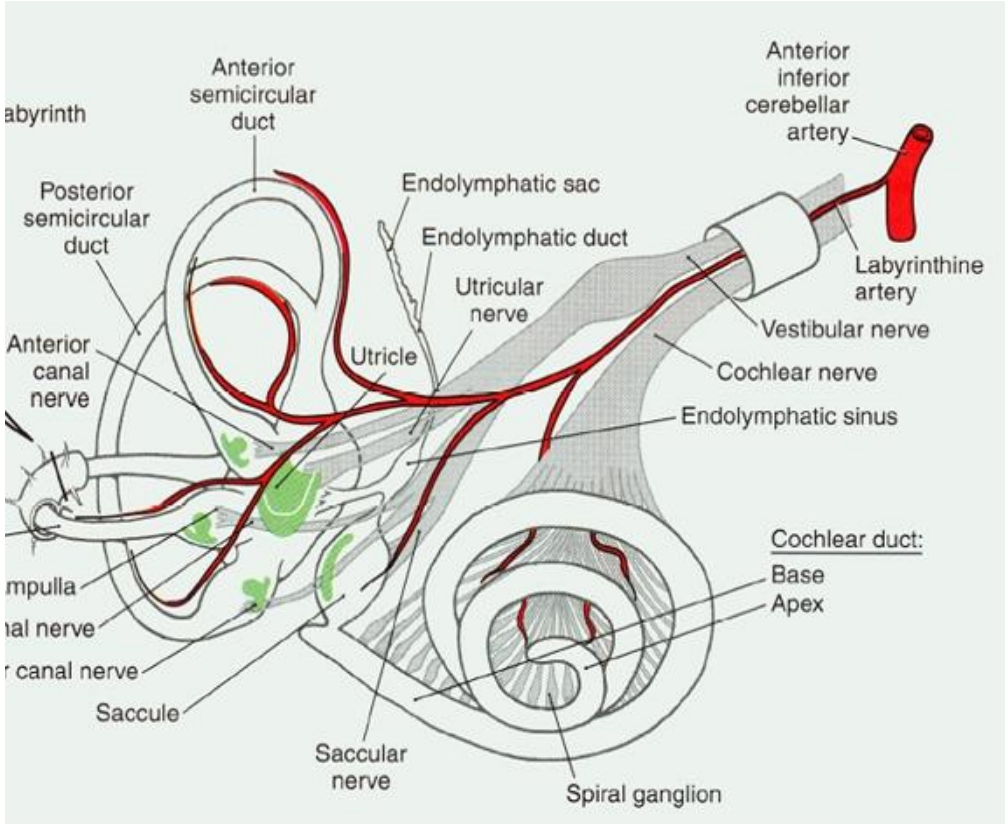
IEDS after gas switch:
- during ascent
- in this case: no gas switch, CCR!

Doolette DJ, Mitchell SJ. Biophysical basis for inner ear decompression sickness. JAP 2003;94:2145-2150

Vascularization of the vestibulum

- animal studies: vestibular blood flow 3-4 x slower compared to cochlear blood flow
- labyrinthine artery is long and slender

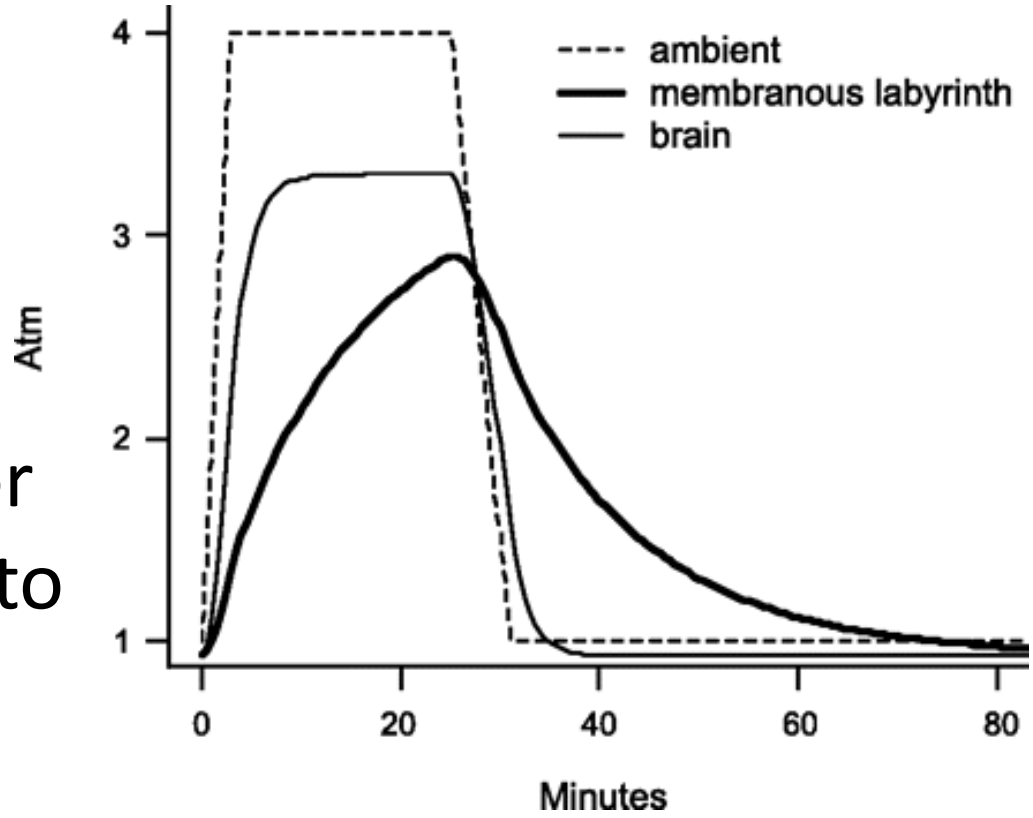
- inner ear is poorly vascularized
- relatively large fluid compartments
- no muscle!
- low oxygen use
- ‘slow tissue’



Nakashima T et al. Effects of anterior inferior cerebellar artery occlusion on cochlear blood flow- a comparison between laser-doppler and microsphere methods. Hear Res 2001;162:85-90

Modelling inner ear gas kinetics

- N_2 Half time inner ear is longer then brain tissue
  - inner ear tissues 8.8 min
  - brain: 1.2 min
- longer period of supersaturation
- low blood flow
- perfect conditions for <u>arterialised</u> bubbles to grow



Mitchell SJ, Doolette DJ. Selective vulnerability of the inner ear to decompression sickness in divers with right-to-left shunt: the role of tissue gas supersaturation. JAP 2009;106:298-301

IEDCS & R > L shunt

- R > L shunt in IEDCS, case series
  - 8 out of 9 IEDCS: 88% Klingmann 2003
  - 28 out of 34 IEDCS: 82% Cantais 2003
  - 24 out of 30 IEDCS: 80% Klingmann 2012
  - 15 out of 18 IEDCS: 83% Klingmann 2007

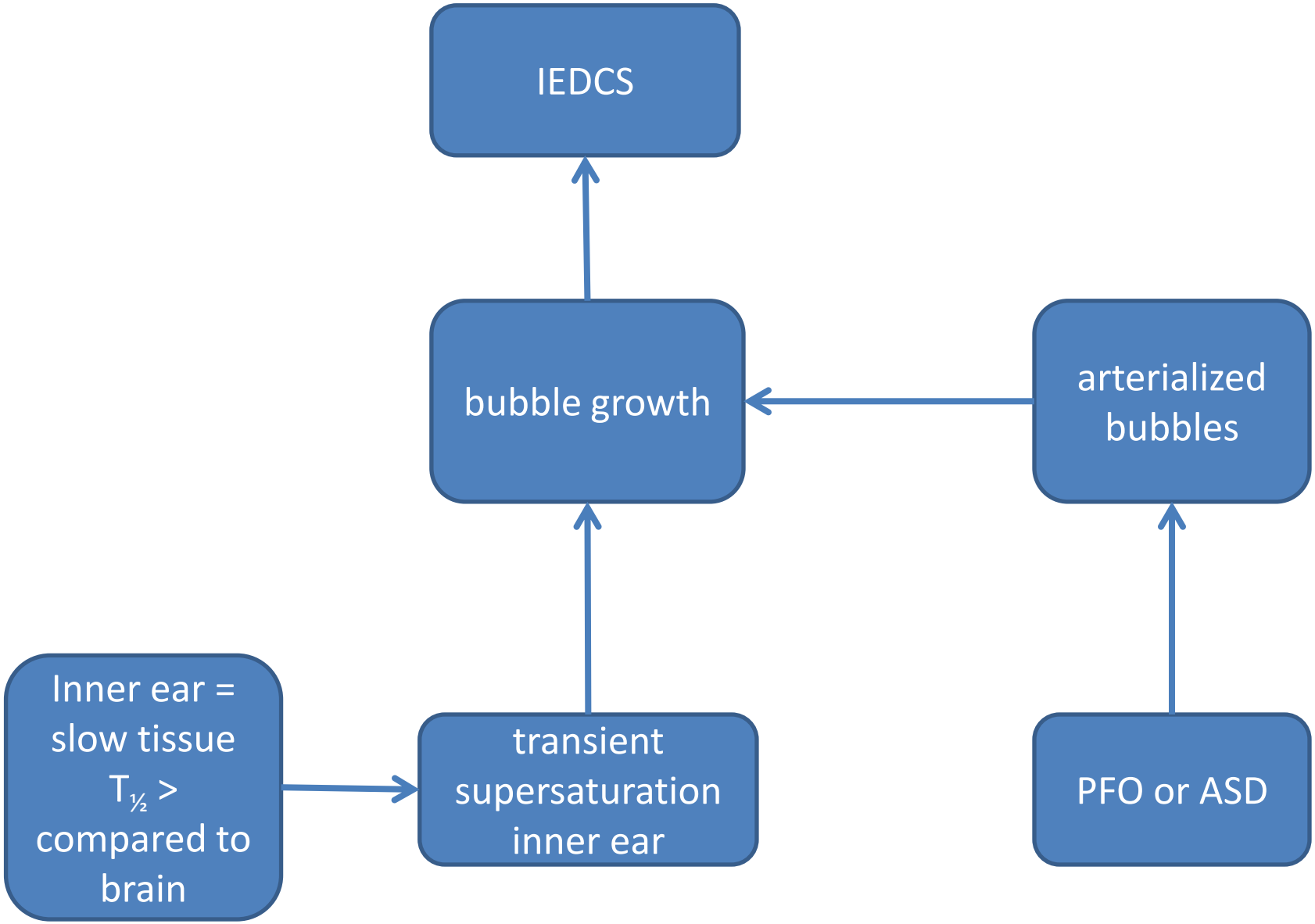
Klingmann C, Benton PJ, Ringleb PA, Knauth M . Embolic inner ear decompression illness: correlation with a right to left shunt . Laryngoscope 2003 ; 113 : 1356 – 61

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: 84 – 8 .

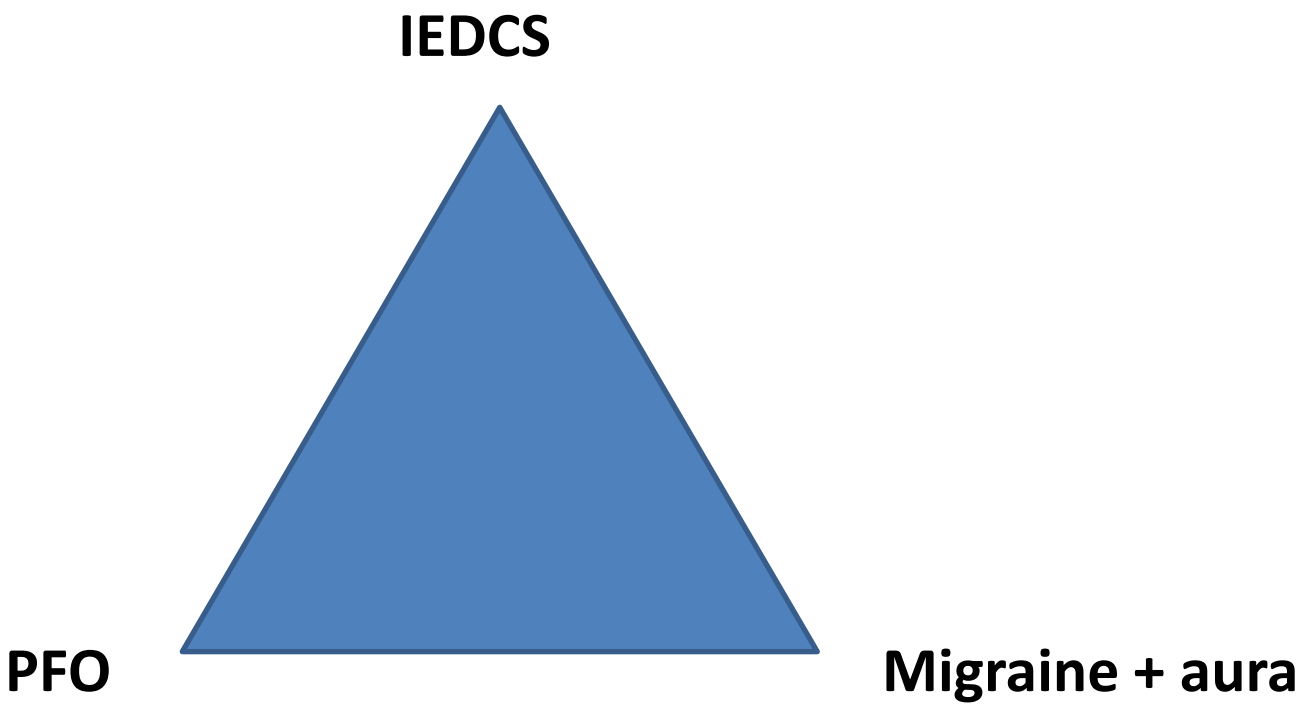
Klingmann C . Inner ear decompression sickness in compressedair diving . Undersea Hyperb Med 2012 ; 39 : 589 – 94

Klingmann c, et al. Barotrauma and decompression ilness of the inner ear: 46 cases during treatment and follow up. Otol Neurotol 2007;28:447-54

The whole picture



Interrelated.....



PFO & aura ± migraine

- Prevalence of R > L shunt in patients with migraine + aura:
  - 41% Del sette 1988
  - 48% Anzola 1999
  - 38% Dowson 2006
- Prevalence of aura ± migraine in patient with a large R > L shunt
  - 52 out of 90 = 57.8% Wilmshurst 2005

PFO in 27.6% of autopsies
- not all PFO's shunt!
- large PFO with a shunt: 7.3 % of population

MIST trial2008: prospective , randomized, multicentre, double blind, placebo controlled
PFO closure: no stat sign effect on migraine

Dowson et al. Migraine Intervention With STARFlex Technology (MIST) Trial A Prospective, Multicenter, Double-Blind, Sham-Controlled Trial to Evaluate the Effectiveness of Patent Foramen Ovale Closure With STARFlex Septal Repair Implant to Resolve Refractory Migraine Headache. Dowson et al. Circulation. 2008;117:1397-1404.)

Chemical or vascular shunt hypothesis

Metabolic functions of the lung:

- PGE
- PGE_2,
- PGF,
- Atrial naturic peptide
- endothelins
- Leukotrienen
- Norepinephrine (30% first pass elimination)
- Serotonin (95% first pass elimination)
- Bradykinin
- Angiotensin I > II
- Adenosine
- AMP, ADP, ATP

Vascular shunt hypothesis: shunting of microemboli normaly filtered by the lung

Deepak J, et al. Non-respiratory functions of the lung. Cont Education in Anaesthesia, critical care & pain advance access 2013, January 11

What about migraine & diving?

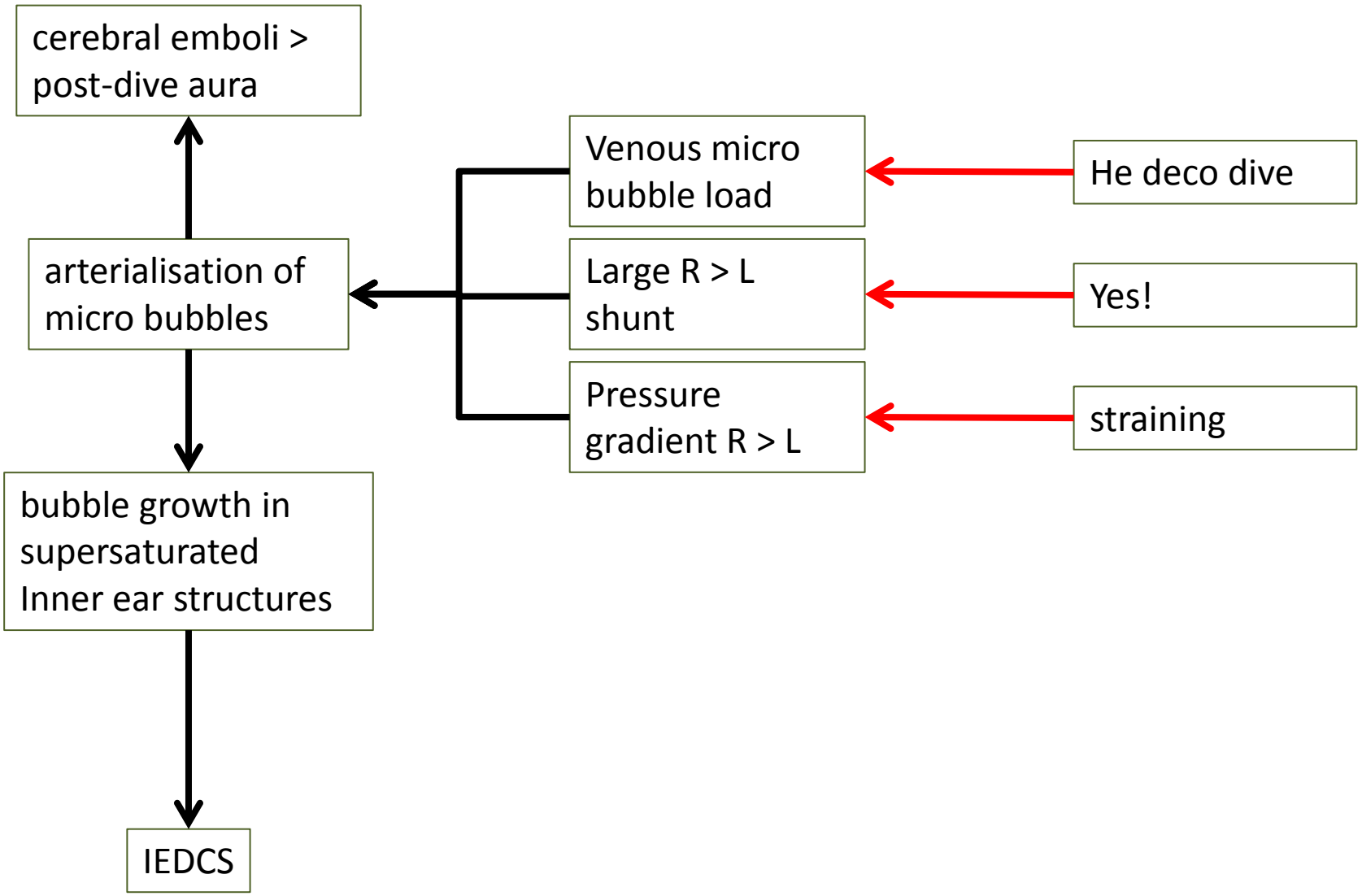
- Wilmshurst described 27 + 32 divers with post dive aura ± migraine.
- All had a large R > L shunt
- Some also had hemimotor or hemisensory symptoms

Do bubbles trigger an aura?

probably! Intravenous micro bubbles: given to patients with migraine + aura & PFO: electrical activity on EEG + headache
This did not occur in patients with PFO without migraine or patients with migraine without PFO

Sevgi EB, et al. Paradoxical air microembolism induces cerebral bioelectrical abnormalitoes and occasionally headache in PFO patients with migraine. J Am heart Assoc 2012; Dec 19
Wilmshurst P, Nightingale S. Relationship between migraine and cardiac right to left shunts. Clin sci 2001;100:215-220
Wilmshurst, et al. Re-evaluation of the relationship between migraine and PFO and other right to left shunts. Cli sci 2005;108:365-367

Back to Sharm.....



Follow up

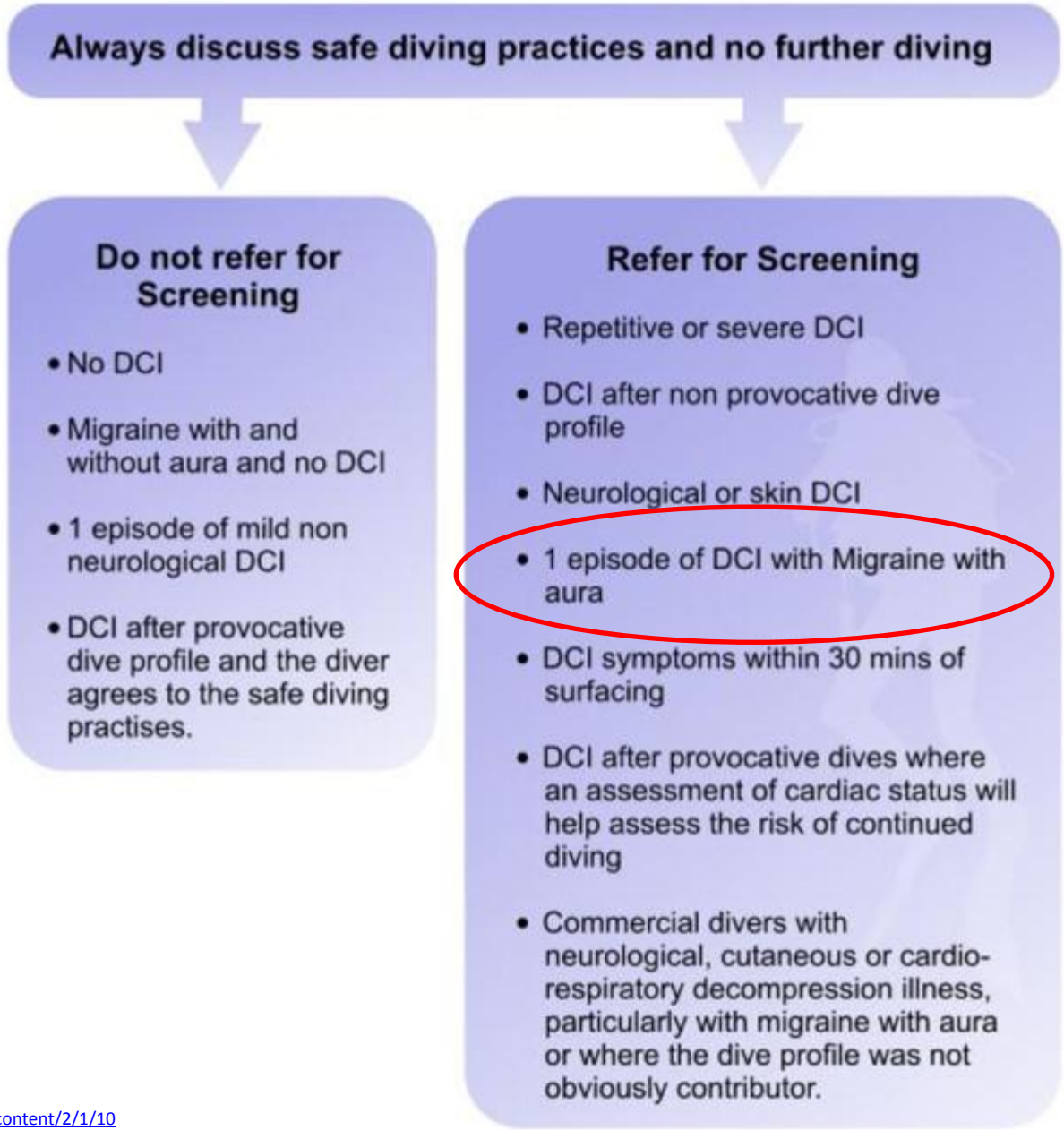
- Patient was advised to have a proper ‘bubble echo’
- bubble echo by Len Shapiro (UK): huge PFO 27 mm with a total white out on valsalva
- percutaneous closure July 2014
- migraine free since!
- minimal residual shunt after 3 months
- started diving again (still on aspirin and clopidogrel)
- started CCR trimix diving again: no more post-dive aura!
- a very happy diver!

IEDCS: management

- same as other DCS
- at the scene: 100% O_2
- recompression in a chamber, ASAP
- case report: recovery HBOT 24h after incident
- permant cochleovestibulare damage in 75%

Klingmann C, et al. Recurrent inner ear decompression sickness associated with a patent foramen ovale. Arch Otolaryngol Head Neck Surg 2002;128:586-8
Klingman C, et al. barotrauma and decompression illness of the inner ear: 46 cases during treatment and follow-up. Otol neurotol 2007;28:447-454

Referral for PFO screening



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