SCUBA Diving, WMH and PFO

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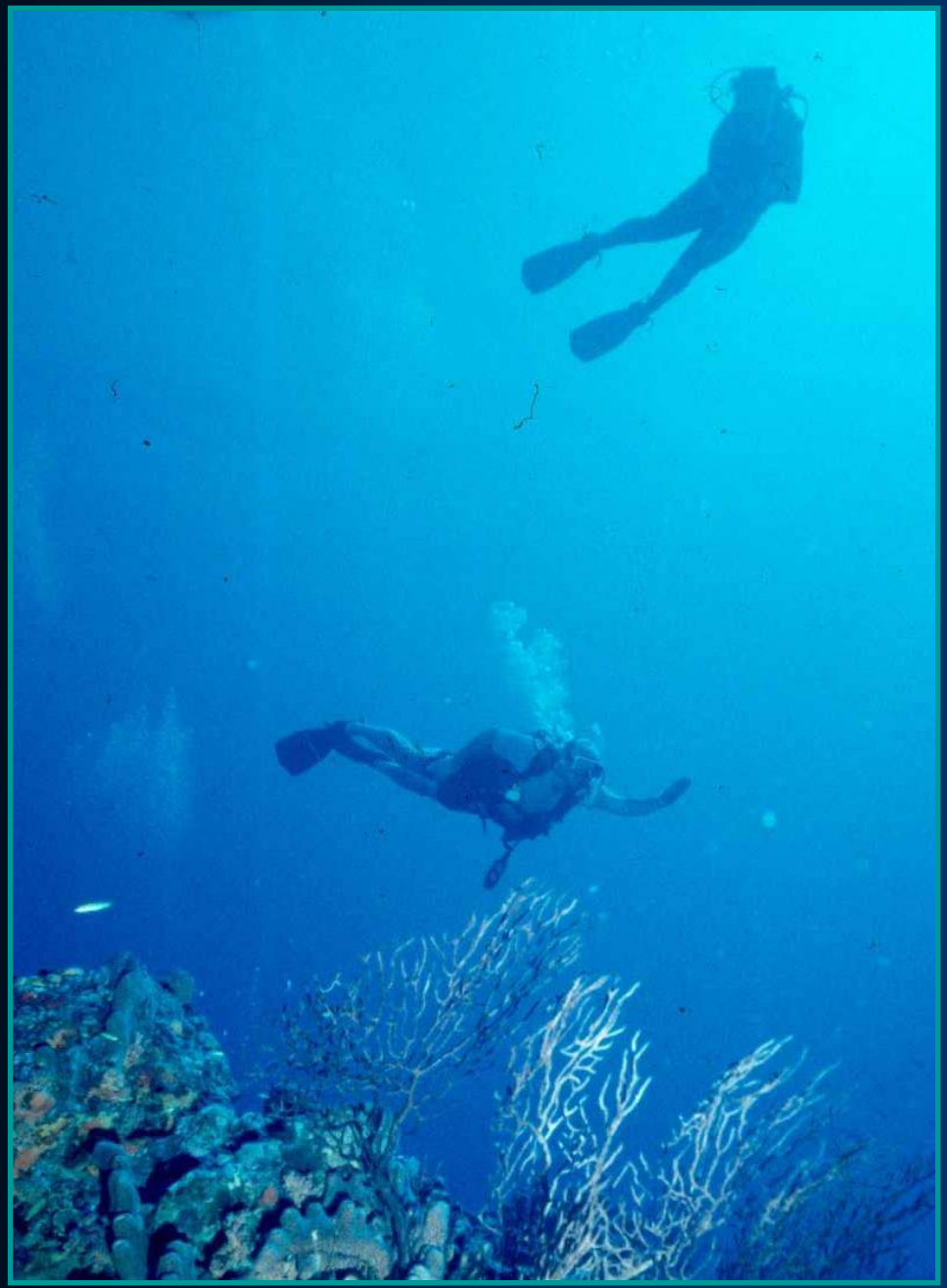


Recent DCI case

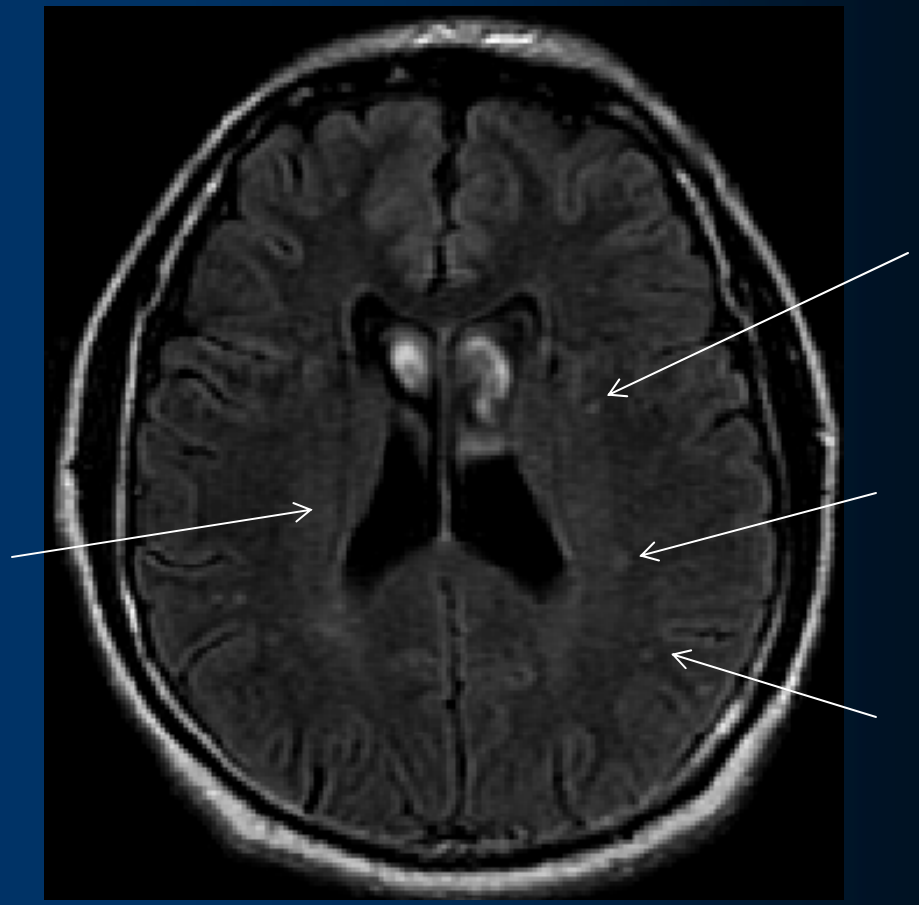
37 yo technical diver, Lake Mead, aircraft: 185 ft/52 min (4 stops, trimex then 50/50; 80/20 O2; PO2 <1.6) On ascent noted shoulder pain, abdominal redness: DCI

+ASD

ASD closed and purchased more expensive gear!

Recent DCI case

- Brain MRI demonstrating several scattered nonspecific punctate foci of abnormal prolonged T2 signal within the cerebral hemispheres.
- Cerebral atrophy slightly greater than expected for age.

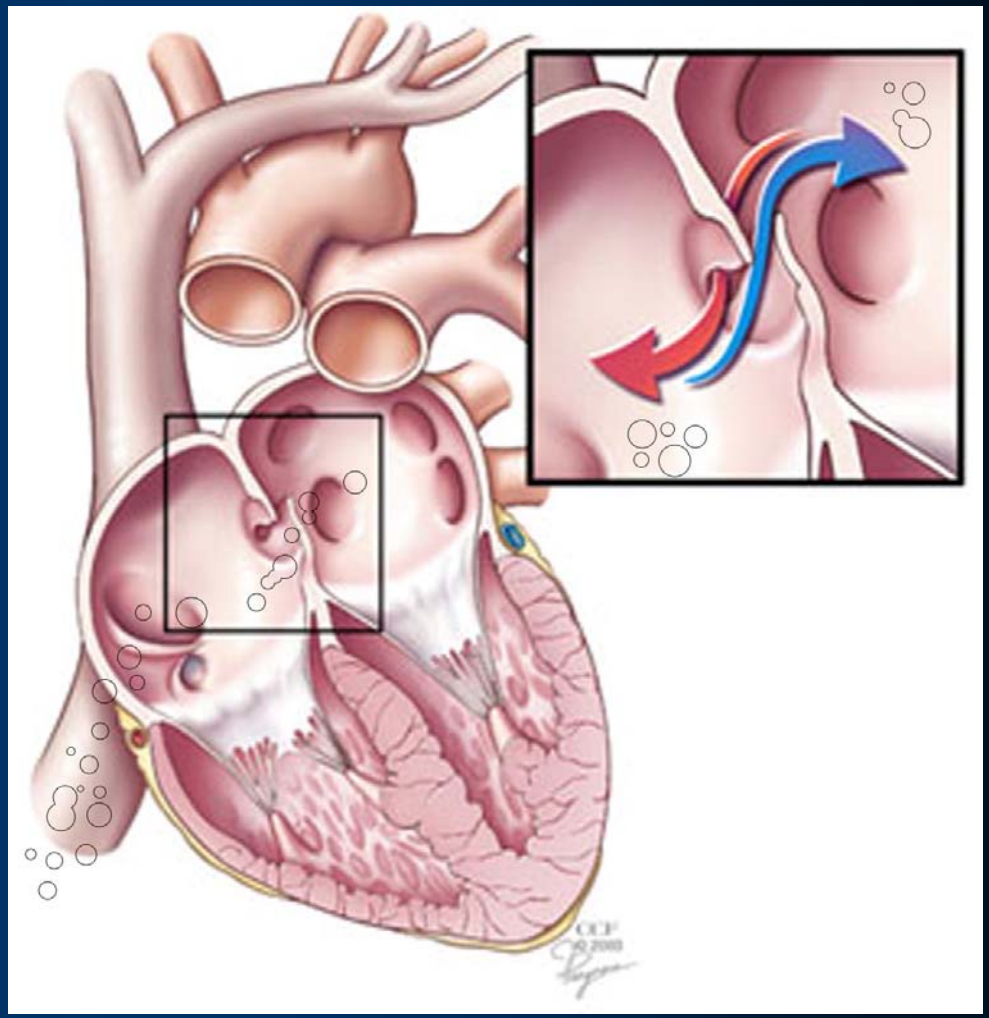


Brain Lesions in Divers

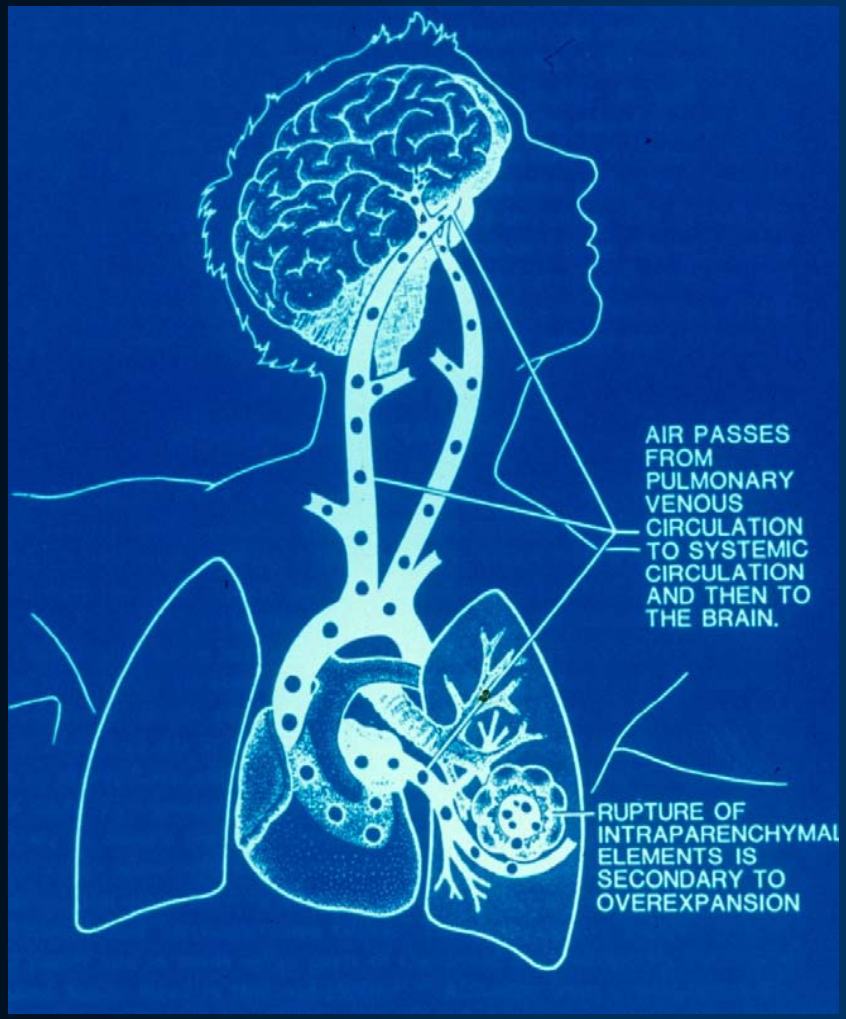
- Risk for neurologic injuries:
  - Decompression sickness
    - With descent tissue and blood N_2 increases. With ascent N_2 can form bubbles in tissues or venous blood. If PFO, bubbles can become arterialized.
  - Arterial gas embolism
    - With ascent gas expands, and can tear alveoli and move into the pulmonary capillary network, then onto the brain and other organs.

PFO and Divers

If gaseous bubbles are present in venous blood (and in divers they often are), bubbles and coagulation - inflammatory debris can cross into the arterial circulation.



Arterial gas embolism



From: Neuman TS. Unusual forms of trauma. *In:* Best W (ed). Trauma: the first hour. Norwalk: Appleton-Century Crafts, 1984. Used with permission.

Diver Down, Lweaver 1989

Brain Lesions in Divers

- Most neuroimaging studies look at only symptomatic divers
- Most divers asymptomatic despite increased prevalence of brain lesions compared to non-diving controls (Reul, et al. 1999)
- Multiple lesions linked exclusively to large right-to-left shunt (Knauth, et al. 1997)

PFO and Brain Lesions in Divers

- Cranial MRI and TEE in 52 sport divers and 52 non-diving controls (Switzerland)
  - First 57 divers who responded, had 200+ dives, adhered to decompression tables
  - 5 divers excluded due to claustrophobia for MRI
  - Controls were healthy hospital staff

Schwerzmann, et al. Ann Int Med, 2001.

Study Protocol

- Diving and health status questionnaire
- MRI (1.5T) with T1, T2, proton density
  - Reviewed independently by 2 blinded radiologists
  - Lesion counted if hyperintense on T2 and proton density images
- TEE in transversal and longitudinal image plane by injection of 2 mL contrast into antecubital vein
  - Direct shunting into left atrium through foramen ovale detected by applying Valsalva maneuver

Schwerzmann, et al. Ann Int Med, 2001.

Results

- PFO in 13/52 divers (25%), 9/52 controls (17%), P=0.2
- Divers were older and smoked more than controls
- Diving habits (# dives, depth) similar between PFO/no PFO groups
- Arterial gas embolism in 4/13 divers with PFO, 2/39 without PFO, P=0.007

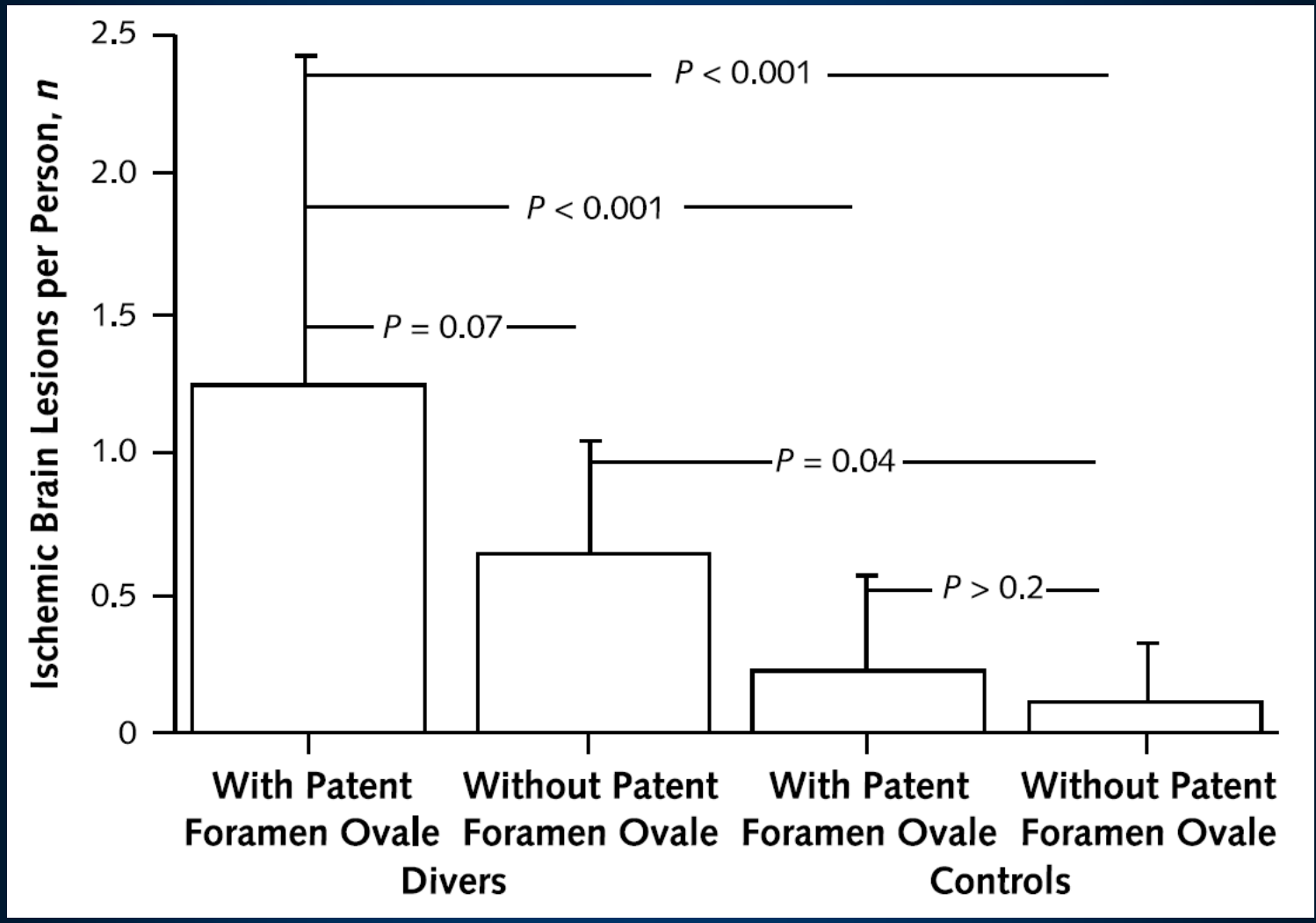
Schwerzmann, et al. Ann Int Med, 2001.

Results (continued)

- PFO increased risk for DCI 4.5-fold, P=0.03
- Brain lesions (OR=5.8, P=0.003)
  - 41 lesions in 19 divers
  - 7 lesions in 6 controls
- Brain lesions and PFO (P<0.001)
  - Divers: 16 lesions w/PFO (n=13), 25 lesions without PFO (n=39)
  - Controls: 2 lesions w/PFO (n=9), 5 lesions without PFO (n=43)

Schwerzmann, et al. Ann Int Med, 2001.

Results (continued)



Schwerzmann, et al. Ann Int Med, 2001.

Conclusions

- Diving increased incidence of brain lesions fivefold
- Twice as many lesions seen in divers with PFO than in divers without PFO
- Decompression illness events did not correlate with MRI findings

Schwerzmann, et al. Ann Int Med, 2001.

Conclusions (continued)

- Presence of PFO rather than diving itself responsible for higher prevalence of clinical events
- Absolute frequency of DCS or AGE is quite low, divers much more likely to be asymptomatic and have brain lesions, leading to possible long-term neurological problems

Schwerzmann, et al. Ann Int Med, 2001.

Further Reading

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