Deep Diving Marine Mammal Blood Supply to Brain

1. Human brain vulnerable to injury following just a few minutes of oxygen deprivation.
2. Additional injury during rapid oxygen repurfusion, due to build up of reactive oxygen and nitrogen groups.
3. Yet deep diving marine mammals can remain underwater for up to 2 hours without neurological or behavioral impairments, despite low blood-oxygen levels which would render humans unconscious.
4. How do these animals avoid ischemic-hypoxic neural damage ?
5. DDMM have up to 10 times as much hemoglobin circulating in blood as humans;
6. DDMM have up to 3 times as much resident globin proteins in brain – neuroglobin and cytoglobin. – discovered in year 2000.
7. Together, these two globin groups provide complementary mechanisms for facilitating oxygen transfer into neural tissues, and for protection against reactive oxygen and nitrogen groups. cytoglobin / neuroglobin

1. DDMM start with higher capillary densities in brain – this morphological characteristic allows achieving same rate of oxygen supply as dogs but at lower blood oxygen gradients, thus increasing tolerance to hypoxia.
2. DDMM facilitate oxygen storage in the blood through increased hematocrit (hemoglobin), which concomitantly restricts fast-swimming behavior due to elevated blood viscosity.
3. DDMM preferentially rely on circulating globin proteins in the brain.
4. Neuroglobin – function in scavenging reactive oxygen and nitrogen groups and subsequent defense against cellular damage during hypoxia.

5. Cytoglobin – has high oxygen affinity, has role in facilitating oxygen transfer and storage.
6. The immediate general response of DDMM to reduced access to air upon submergence is enhanced delivery of oxygen through circulating globins in the intracranial vasculature.
7. By maintaining an exceptionally rich circulating globin pool, delivery of oxygen to brain can be preserved despite low blood oxygen partial pressures.
8. Resident globins provide a second level of support by facilitating the movement of oxygen from blood to neural tissues against a progressively lower oxygen gradient – similar to myoglobin.
9. Other protective mechanisms – Brain cooling and concomitant declines in tissue metabolism.
10. Significance for humans ??
    a. variability in globin levels illustrates capacity of mammalian neural tissue to protect itself under extreme environmental challenges,
    b. Not a single unified response.
    c. Interrelated safety mechanisms mediated by an array of globin proteins which may be mobilized.
    d. Presence of each globin in mammalian brain seems malleable, leading to prospect of novel comparative approach for investigating as well as preventing oxygen-mediated neural injury in humans.

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Running, Swimming and Diving Modifies Neuroprotecting Globins in Mammalian Brain,
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