Commentary: Altitude, acclimation, arterial alterations in retina and choroid

Altitude regions are usually defined as high altitude (1500–3500 m; 5000–11,500 ft), very high altitude (3500–5500 m; 11,500–18,000 ft), and extreme altitude (>5500 m; >18,000 ft). Generally, lowlanders can ascend and fully acclimatize to altitudes of about 5000 m for continuous residence. Up to 7000 m, mountaineers can acclimate for short stay or some days, and it is impossible to do so beyond 8000 m by humans.

High-altitude illness (HAI) is said to occur with altitude above 2500 m (8200 ft) and is generally characterized by symptoms of headache, nausea, vomiting, and tiredness. It may affect the lungs, brain, and eyes differently among individuals.

High-altitude retinopathy (HAR) is one of the four clinical entities of HAI, the other three being acute mountain sickness (AMS), high-altitude cerebral edema (HACE), and high-altitude pulmonary edema (HAPE). The latter two are life-threatening conditions, but occur very rarely.

Hypobaric hypoxia at high altitudes induces several compensatory physiologic mechanisms to hypoxemia, causing increase in cardiac output and ventilation, such as modification of blood flow by local and systemic autoregulatory adjustments in regional vascular systems, a right shift of the oxygen–hemoglobin dissociation curve, and secondary polycythemia resulting in an increased hemoglobin concentration and hematocrit. These changes, exacerbated by physical exertion and Valsalva effects, are believed to cause physiologic and pathologic retinal changes in individuals at high altitudes.
Increased retinal blood flow, decreased retinal circulation time, retinal vasodilation, and an absolute increase in retinal vascular blood volume are the important autoregulatory responses aimed at maintaining tissue oxygenation in eyes exposed to chronic hypoxia. These regional compensatory responses typically cause a clinically observable increase in the diameter and tortuosity of retinal vessels and disk hyperemia.[3,4]

Choroidal vessels can also autoregulate, but early studies suggest that choroidal vessels do not operate normally at full-flow capacity. Enhanced depth imaging Spectral Domain Optical Coherence Tomography (EDI SD-OCT) has shown a small, but significant increase in choroidal thickness upon acute altitude exposure to 4559 m.[4] This increase in choroidal blood flow was not related to acute motion sickness and was fully reversible after return to low altitude.

HAR encompasses a spectrum of pathologic retinal changes occurring in unacclimatized individuals exposed to hypobaric hypoxia encountered at high altitudes and may reflect individual susceptibility to pathology. Usually, it is asymptomatic and typical features include retinal hemorrhages in periphery, predominantly in macula, and papilledema. It resolves spontaneously on descent to lower altitudes. Vitreous hemorrhage following climbing high altitude can be one of the manifestations of HAR.[3]

High altitude does not adversely affect visual acuity and contrast sensitivity.

Scotopic vision may be affected if supplemental oxygen is not used.[4] Though HAR of mild degree does not affect vision, it has a predictive value for the development of HACE.[8]

Though central foveal thickness alteration was not strikingly different, it was statistically significant in a recent study on inhabitants of high altitude, living for more than 10 years.[7]

Visible light optical coherence tomography angiography (OCTA) facilitates local microvascular oximetry in the human retina. Angiography enables accurate localization of microvasculature down to the capillary level, and thus enables oximetry at vessels 100 μm in diameter measuring O2 saturation.[8]

High-altitude hypobaric hypoxia affects the function of the highly sensitive macular region. This suggests that the exposure of persons with diseases such as age-related macular degeneration, tapetoretinal degeneration, or diabetic retinopathy to high altitudes may influence the disease progression. This population should consider proper acclimatization and avoid prolonged high-altitude exposure.

Multifocal electroretinogram (ERG) used to record the electrophysiological changes in retina of individuals at high altitude demonstrated the amplitude changes. In one such study, the central macula Multifocal electroretinogram (MF-ERG) responses were significantly reduced 1 week after high-altitude exposure and recovered during the subsequent week.[9]

Molecular studies have also demonstrated changes in the levels of interleukin (IL)-10 and IL-7R. They were strongly downregulated under hypoxic conditions. It is not clear if these findings are relevant in HAR.[9]

Altitude changes have been noticed with improved concentrations of oxygen on descent to sea levels in high-altitude inhabitants as well.[9]

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