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Analysis by NASA's VESGEN Software of Vascular Branching in the Human Retina

with a Ground-Based Microgravity Analog

Purpose.
Significant risks for visual impairment were discovered recently in astronauts following spaceflight, especially after long-duration missions. We hypothesize that microgravity-induced fluid shifts result in pathological changes within the retinal vasculature that precede visual and other ocular impairments. We therefore are analyzing retinal vessels in healthy subjects before and after head-down tilt (HDT), a ground-based microgravity analog with NASA's VESsel GENeration Analysis (VESGEN) software.

Methods.
Spectralis® infrared (IR) fundus images were collected from both eyes of 6 subjects before and after 70 days of bed rest at 6 degree HDT (NASA Campaign 11). For our retrospective study, branching patterns in arterial and venous trees are mapped by VESGEN into vessel branching generations (G_x) that are quantified by parameters such as densities of vessel length (L_v), area (A_v), number (N_v) and fractal dimension (D_f) as described previously for diabetic retinopathy (IOVS 51(1):498). Results are further assigned by VESGEN into groups of large (G_{1-3}), medium (G_{4-6}) and small ($G_{\geq 7}$) vessels.

Results.
All subjects remained asymptomatic throughout duration of HDT. To date, we have analyzed one IR image from each of the 12 eyes. Interestingly, two groups of the masked study population identified by VESGEN are distinguished by the presence or absence of small veins ($G_{\geq 7}$). For example, $L_{\geq 7}$ and $A_{v \geq 7}$ are 2.7 ± 1.3 E-4 px/px^2 and 7.2 ± 3.6 E-4 px^2/px^2 in 6 retinas, but 0 in the other 6 retinas. Nonetheless, the space-filling properties of the entire venous trees were remarkably uniform by all parameters, such as $D_f = 1.56 \pm 0.02$ for 6 retinas with $G_{\geq 7}$ and 1.55 ± 0.02 for retinas without $G_{\geq 7}$. No small arteries ($G_{\geq 7}$) were detected.

Conclusions.
For our preliminary masked analysis, two groups of venous trees with and without small veins ($G_{\geq 7}$) were clearly revealed by VESGEN. Upon completing all images and unmasking the subject status of before and after HDT, we will determine whether differences in the presence or absence of small veins are important correlates, and perhaps reliable predictors, of other ocular and physiological adaptations to prolonged head-down tilt and microgravity. Clinical methods for examining adaptive microvascular remodeling in the retina to microgravity space flight are not currently established.

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