Effects of Deep Space Radiation on Lymphatic Vessel Structure and Function

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Background

The cardiovascular system has been shown to adapt to spaceflight exposure, where astronauts are subjected to environmental factors such as deep-space radiation and microgravity. These environmental changes may cause crew adaptations and increased risk developing adverse medical conditions, such as cardiovascular disease, facial edema and spaceflight associated neuro-ocular syndrome (SANS).

The lymphatics are involved with cardiovascular health, fluid regulation, and our immune system responding to different conditions. The superficial cervical lymphatic is found in the neck and plays a role in moving fluid away from the head.

This study investigated if spaceflight radiation exposure leads to long-term lymphatic structure and function changes, predisposing astronauts to increased risk of developing lymphatic system dysfunctions, including edema and SANS.

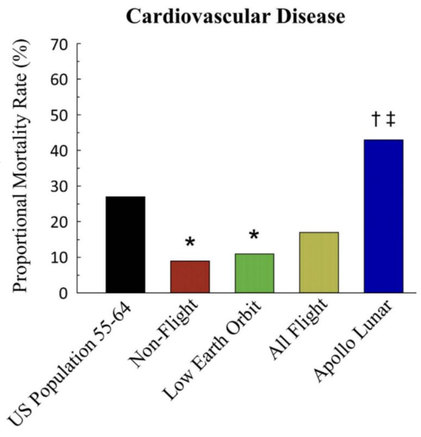

Figure 1. The proportional mortality rate due to Cardiovascular disease of astronauts. (See reference 1).

Methods

Rodents were treated with simulated deep space radiation and left to recover for 9-12 months (equivalent to ~20 human years), to investigate the long-term effects of radiation exposure. Superficial cervical lymphatic vessels were isolated and myography experiments were completed with them. The vessels were exposed to 1, 3, 5, 7, and 9 cm of pressure and images were taken throughout the vessel's contraction cycle at each of these pressures. The average width of each vessel at systole and diastole was collected and used to obtain systolic and diastolic volume.

$$Structure = Vessel\ Diameter$$

$$Ejection\ Fraction\ (\%) = \frac{Diastolic\ Volume - Systolic\ Volume}{Diastolic\ Volume} \times 100\%$$

$$Lymphatic\ Pump\ Flow = Contraction\ Frequency \times Ejection\ Fraction$$

$$Function = Lymphatic\ Pump\ Flow$$

Preliminary Results

Lymphatic vessel diameters are currently still being collected and analyzed in order to determine lymphatic pump flow (see Figure 2). Preliminary results from contraction frequency data suggest a statistically significant increase in contraction frequency as a result of exposure to radiation at various pressures ($p = 0.05$, see Figures 3 and 4).

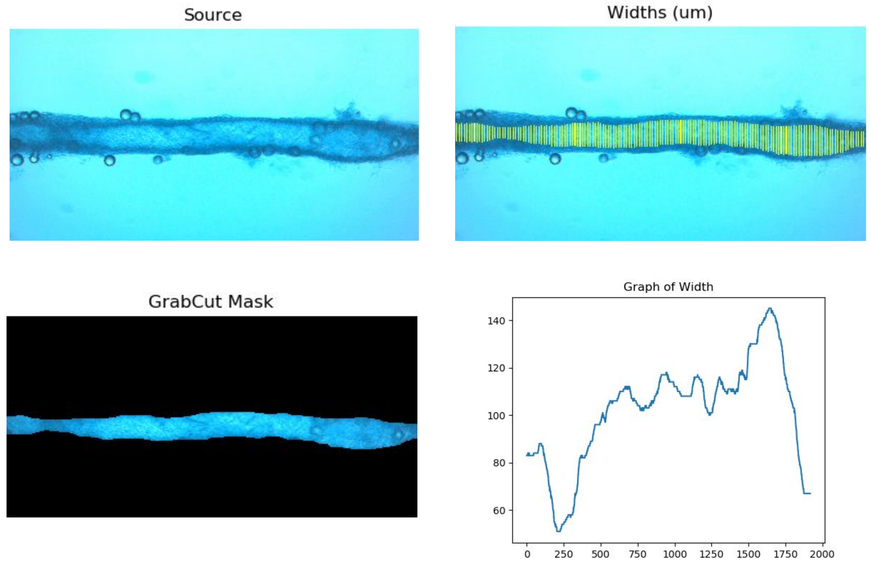

Figure 2. Graph outputs generated when collecting average vessel diameter at 5 cm pressure.

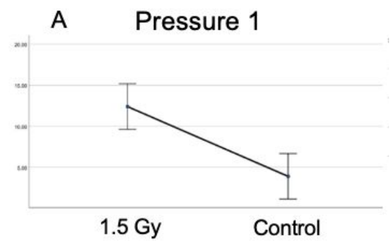

Figure 3. Increased average contraction frequency at 1 cm pressure ($p>0.0001$) when exposed to radiation.

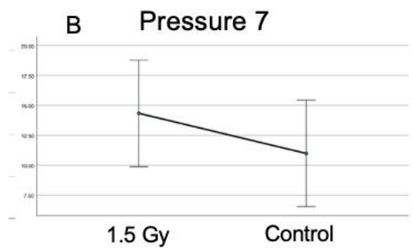

Figure 4. Increased average contraction frequency at 7 cm pressure ($p=0.286$) when exposed to radiation.

Discussion

- As more people travel to space, we require increasing our understanding of the effects of spaceflight on physiology.
- Using simulated deep space radiation allows this variable of interest to be isolated.
- Preliminary results suggest the lymphatic system adapts to deep space radiation exposure and that these adaptations are long-term.
- Future results will show how deep space radiation exposure leads to specific biomedical adaptations with the lymphatic system to identify crew risk to developing elevated risk of lymphatic dysfunction and conditions such as edema or SANS.
- As one of the first studies to analyze effects of radiation on in vivo lymphatic vessels, our results will also contribute to our understanding of clinical lymphoedema as seen on Earth, experienced by cancer patients previously exposed to radiation treatments.

Future Directions

Similar studies are being completed using the same procedures to analyze the singular and combined effects of microgravity and radiation on lymphatic vessel structure and function.

References

1. Delp MD, Charvat JM, Limoli CL, Globus RK, Ghosh P. Apollo lunar astronauts show higher cardiovascular disease mortality: possible deep space radiation effects on the vascular endothelium. Scientific reports. 2016 Jul 28;6(1):1-1.

Acknowledgements

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