AJNR

Reply:

Donna R. Roberts, Joe Tidwell and J. Andrew Taylor

AJNR Am J Neuroradiol 2024, 45 (5) E5
doi: https://doi.org/10.3174/ajnr.A8278
http://www.ajnr.org/content/45/5/E5

REPLY:

We thank Drs Bateman and Bateman for their comments. In their letter[1] and in their review,[2] Bateman and Bateman highlight the limitations of the head-down tilt bedrest model as an analog for cerebrovascular changes that may occur during spaceflight. In this regard, we stress the importance for space agencies and commercial spaceflight providers to prioritize studies of cerebral perfusion in astronauts.

In addition to the limitations inherent in the head-down tilt bedrest model, it is important to keep in mind the difficulties of measuring perfusion during spaceflight and the limitations of the various methods used for measuring cerebral perfusion. Due to the constraints of the human spaceflight setting, conventional imaging techniques for measuring cerebral perfusion such as xenon-enhanced CT, SPECT, PET, dynamic perfusion CT, and MR imaging perfusion[3] may be used only on the ground before and after spaceflight. In this situation, without inflight data, it is unclear whether measurements made after spaceflight reflect inflight physiology or, alternatively, an adaptive response to returning to one gravity on Earth.

Furthermore, each of these methods has limitations concerning the quantification of CBF.[3] In particular, arterial spin-labeling (ASL) MR imaging, as used by Tidwell et al,[4] requires adjustment for individual hematocrit levels to avoid overestimation of perfusion. This is important to take into account when evaluating longitudinal changes in perfusion by ASL MR imaging in individuals who may develop anemia such as patients with idiopathic intracranial hypertension or astronauts undergoing long-term spaceflight as pointed out by Bateman and Bateman.[1]

Ideally, CBF would be measured on-orbit during spaceflight. Several investigators have used Doppler ultrasound inflight; however, as Bateman and Bateman[2] point out in their review, mixed results have been obtained using Doppler ultrasound, which indirectly infers CBF based on CBF velocity.

Another method that may be suitable for on-orbit use is near-infrared spectroscopy. In a study performed as part of a private astronaut mission to the International Space Station sponsored by Axiom Space in 2023, the Axiom Mission 2 crew used near-infrared spectroscopy to measure CBF during spaceflight.[5] We are awaiting, with interest, the results of this study.

Given the complexity of factors that may contribute to altered cerebral perfusion and spaceflight-associated neuro-ocular syndrome (SANS) development, ultimately a multimodal approach, using both inflight and ground-based methods for measuring cerebral perfusion in astronauts, will be needed to gain a better understanding of the impact of spaceflight on cerebrovascular physiology. In addition, these studies would provide essential data for developing evidence-based protocols to reduce the risk of the occurrence of an inflight neurovascular emergency, such as stroke, among future space travelers.

REFERENCES

1. Bateman GA, Bateman AR. **Spaceflight-Associated Neuro-Ocular Syndrome and Idiopathic Intracranial Hypertension: Can Anemia and Hyperemia Underlie Both**? *AJNR Am J Neuroradiol* 2024;45:E4 CrossRef
2. Bateman GA, Bateman AR. **A perspective on spaceflight associated neuro-ocular syndrome causation secondary to elevated venous sinus pressure.** *NPJ Microgravity* 2022;8:3 CrossRef Medline
3. Wintermark M, Sesay M, Barbier E, et al. **Comparative overview of brain perfusion imaging techniques.** *J Neuroradiol* 2005;32:294–314 CrossRef Medline
4. Tidwell JB, Taylor JA, Collins HR, et al. **Longitudinal changes in cerebral perfusion, perivascular space volume, and ventricular volume in a healthy cohort undergoing a spaceflight analog.** *AJNR Am J Neuroradiol* 2023;44:1026–31 CrossRef Medline
5. AXIOM SPACE. **Ax-2 mission bolsters opportunities for innovation and scientific research in space.** https://www.axiomspace.com/missions/ax2/research. Accessed March 19, 2024

Donna R. Roberts
Department of Radiology and Radiological Science
Medical University of South Carolina
Charleston, South Carolina

International Space Station National Laboratory
Melbourne, Florida

Joe Tidwell
J. Andrew Taylor
Department of Radiology and Radiological Science
Medical University of South Carolina
Charleston, South Carolina

http://dx.doi.org/10.3174/ajnr.A8278