SPACE FLIGHT, HEAD-OUT WATER IMMERSION, AND RENAL DISEASE: BETTER MODELS NEEDED TO UNDERSTAND MECHANISTIC CHANGES

CLAIRE M. LATHERS
Office of the Director, Center for Veterinary Medicine, U.S. Food and Drug Administration. Rockville, MD 20855

INTRODUCTION

Studies in the past 14 years by Lathers, Charles, Bungo, Mukai et al (1) at the Johnson Space Center/NASA discuss similarities and differences in physiological data obtained in ground-based models to simulate space flight. Data from models of head-down and head-up tilt, 17-wk horizontal bed rest with lower body negative pressure (LBNP), and parabolic flight were compared with data from space flight of different durations: Apollo, Skylab, Shuttle, Salyut Soyuz, and Mir flights. This study compares ground-based analogues of space flight with published studies of head-out water immersion and: pharmacologic agents, persons with and without legs, and patients with renal failure, renal transplants, and essential hypertension.

RESULTS AND DISCUSSION

Lathers et al studied the magnitude and time frame of changes in plasma volume (2) and orthostatic tolerance (3) during horizontal bed rest and compared the data in water immersion studies. (4) Heart rate response to LBNP during and after 17-wks of bed rest demonstrated the heart rate was slightly elevated. LBNP was a useful tool to evaluate orthostatic response during bed rest. Plasma volume, Hct/Hb values, showed no change on Day 15, a slight decrease on Day 36, a further decrease on Day 42, and no change at the end of bed rest, Day 106. Although plasma volume decreased by only 4 to 5%, orthostatic changes were still observed. The decrease in plasma volume by itself does not solely appear to be responsible for orthostatic changes. Frey et al (5) reported a 10% decrease in the plasma volume after lasex-induced hypovolemia. LBNP heart rate response at 50 mmHg was slightly increased and concluded a 10% decrease in plasma volume did not, by itself, alter the cardiovascular response to orthostatic stress. The data suggest that other mechanisms, such as autonomic dysfunction, may cause orthostatic intolerance after space flight. Comparison of plasma volume changes during head-down bed rest and water immersion models revealed head-down bed rest produces results much closer to those obtained during space flight. During horizontal bed rest plasma volume changes did not mimic as closely the changes recorded during space flight. Both head-down bed rest and horizontal bed rest resulted in orthostatic intolerance. During water immersion, all changes are very acute: plasma volume increases initially but decreases later. The duration of weightlessness induced by parabolic flight is too short to see the relationship between changes in plasma volume and orthostasis. It is concluded that no given Earth bound model accurately reflects the physiological changes of space flight.

CONCLUSIONS

Wang et al (6) suggest studying fluid regulation and renal variables with head-up tilt (body positive pressure) or head-down tilt plus upper pressure at various angles and levels to more closely simulate 0-g. Such experiments would expand the studies of Lathers et al in 1991. (1) Similarities in space flight responses and clinical symptoms of acute renal failure, i.e., orthostatic hypotension and tachycardia, exist but isotonic saline counters orthostatic hypotension in astronauts while hypotonic saline is most often used in patients. Chronic renal failure exhibits decreased renal function and calcium, phosphate, and bone abnormalities, more like very long duration space flight. During water immersion and bed rest body tissues are compressed by pressure from gravity, while microgravity exerts a negative pressure around the body. Differences in renal function reported for space flight and ground-based models reflect differences in the physical forces affecting the tissues and hemodynamics. Understanding differences in ground-based models and space flight will develop better countermeasures for the physiological effects of space flight and new treatment regimens for patients with renal failure. (Opinions are the author's and do not reflect U.S. FDA policy).

REFERENCES

(1) Lathers C. M. et al (1991) *J Clin Pharmacol* 31, 893-903. (2) Lathers C.M. and Charles J.B. (1996) *Aviat Space Med* 67, A35. (3) Lathers C.M. et al (1994) *J Clin Pharmacol* 34, 563-570. (4) Lathers C.M., Charles, J.B., Mukai, C. (1999*) 4th Int'l Head-out Water Immersion Sym*, Graz, Austria. (5) Frey M.A. et al (1994) *J Clin Pharmacol* 34, 387-393. (6) Wang D.S. et al (2000) Inst Space Medico Engineering 226-230.