

HEAD-OUT WATER IMMERSION AND HYPERTENSION. LESSONS LEARNED FOR SPACE FLIGHT

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INTRODUCTION. Essential hypertension (EH) is a very common clinical disorder, occurring in up to 25% of the U.S. population. The pathophysiology of essential hypertension is complex and remains poorly understood. As space travel becomes more common, it may be that individuals who are presymptomatic hypertensives prior to departing on a very long duration space flight journey will develop hypertension during the flight or that individuals known to have hypertension will fly. We have reviewed the available data on hypertension in models which simulate microgravity and discuss the potential implications for treatment of hypertensive individuals during very long duration space travel and for patients here on Earth.

METHODS. We performed a MEDLINE search to obtain articles relating to hypertension, water immersion, and space (microgravity).

RESULTS. Head out water immersion (HOWI) resulted in a greater natriuresis in patients with EH compared to control individuals (1-3). The mean arterial pressure (MAP) fell after HOWI in patients with EH but there was no change in MAP in normal controls (1). From the standpoint of renal hemodynamics, there was no significant change in the glomerular filtration rate in either group. The effective renal plasma flow was lower in hypertensive patients under baseline conditions, but increased in both groups following HOWI. The renal precapillary vascular resistance prior to HOWI was markedly higher in the EH subjects compared to controls, and fell to a greater extent after HOWI. Thus the exaggerated natriuresis seen in the EH patients appeared to be due to renal vasodilatation.

However, the natriuretic response to HOWI may vary among hypertensive individuals. Coruzzi et al (2) classified EH patients according to salt sensitivity and found that a greater fall in MAP during a low-salt diet (salt sensitivity) was associated with a more pronounced natriuretic response during HOWI. Epstein et al (3) found only a fraction of EH patients developed an exaggerated natriuresis following HOWI.

In regard to hormonal systems involved in blood pressure control, HOWI has been shown to cause an increase in plasma atrial natriuretic peptide (ANP) in patients with EH and normotensive controls. HOWI reduced plasma renin activity in normotensive controls and to a greater extent in individuals with EH (4,5). An earlier study by Coruzzi et al (6), reported water immersion suppressed the high peripheral renin levels of patients with renovascular hypertension in spite of an autonomic renin secretion from the stenotic kidney, a significant reduction of blood pressure, and an increased distal tubule sodium concentration.

Clonidine suppressed plasma adrenaline, plasma noradrenaline, urinary noradrenaline excretion, and mean arterial blood pressure in healthy subjects (7). During water immersion blood pressure remained constant in both placebo and clonidine groups, when compared with pre immersion values. Suppression of plasma catecholamines and urinary noradrenaline in response to water immersion during placebo was similar after clonidine. Clonidine did not affect renal volume excretion, but did cause a significant attenuation of the immersion-induced stimulation of natriuresis. The renal capacity to excrete sodium was impaired during moderate blood pressure reduction by short-term sympathetic inhibition with clonidine while regulation of blood pressure in response to central hypervolemia was maintained.

CONCLUSIONS. On the basis of these HOWI studies, it appears that the blood pressure in hypertensive individuals may be reduced in the microgravity simulation induced by HOWI, but not necessarily to normal levels. The pathophysiologic findings of these studies may have implications in regard to the pharmacologic treatment of hypertension in individuals who may be presymptomatic prior to initiation of space flight but develop hypertension during long duration flight or in hypertensives who fly. The fact that these patients may undergo a spontaneous diuresis and suppression of the renin-angiotensin system suggests that other classes of antihypertensive agents aside from diuretics or agents which act on the renin-angiotensin system may be more effective. This must be confirmed in space, as none of the ground-based microgravity models have been found to reproduce the changes in fluid and electrolyte balance or hormonal changes found during space travel.

REFERENCES. (1) Coruzzi et al (1988) *Kidney Int* 33:875-880. (2) Coruzzi et al (1993) *Scand J Clin Lab Invest* 53: 593-599. (3) Epstein et al (1986) *Hypertension* 8:422-432. (4) Larochelle P. et al (1994) *Am J Hypertens* 7: 120-8. (5) Chudek et al (1997) *Kidney Blood Press Res* 20: 406-410. (6) Coruzzi et al (1985) *Clin Sci* 68:609-612. (7) (Kreutz et al (1996) *Acta Physiol Scand* 156:1-7.