LOWER BODY NEGATIVE PRESSURE EFFECTS ON JUGULAR HEMODYNAMICS IN PARABOLIC FLIGHT

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INTRODUCTION

Microgravity induces a headward fluid shift that alters venous hemodynamics and has been associated with stagnant and retrograde internal jugular vein (IJV) flow [1], including the first documented case of in-flight IJV thrombosis aboard the International Space Station (ISS) [2]. Lower body negative pressure (LBNP) has emerged as a promising countermeasure to reverse cephalad fluid shifts [3,4]. However, its physiological effects in true microgravity remain poorly characterized. Previous ISS studies have examined only a single LBNP level, leaving the dose-response relationship unexplored.

METHODS

This case report describes the first systematic application of graded LBNP (0, –20, and –30 mmHg) during microgravity achieved via parabolic flight in a single female participant to obtain IJV dose-responses. Matching baseline measurements were collected in the supine position under terrestrial gravity. Left and right IJV cross- sectional area, IJV pressure, and IJV flow were assessed using the Butterfly iQ3 ultrasound device and the CPMX1 device (Compremium AG). To improve characterization of venous flow dynamics, we developed a continuous metric, the Flow Directionality Index (FDI), derived from time-based components of Doppler waveforms to quantify antegrade, retrograde, and stagnant flow.

RESULTS

IJV cross-sectional area (IJVA) was consistently higher during 0 g compared with the 1 g supine baseline. Specifically, the left IJVA exhibited an average increase of 15.2% from 1 g baseline to 0 g flight conditions. In contrast, IJV pressure (IJVP) was lower in 0 g, with the left side showing an average reduction of 34.3% relative to 1 g baseline values. Graded LBNP reduced both variables in a dose-dependent manner across all gravity conditions. During flight, left IJVA decreased from 71.3 mm2 at 0 mmHg to 26.6 mm2 at –30 mmHg. Over the same LBNP range, left IJVP declined from 15.8 mmHg to 8.9 mmHg. Flow analysis revealed impaired venous return in 0 g compared to 1g at 0 mmHg LBNP, with progressive improvements in FDI at –20 and –30 mmHg. The FDI provided greater granularity than traditional categorical flow grading, revealing subtle differences in flow quality not captured by existing methods.

DISCUSSION

This study provides the first dose-response characterization of IJV hemodynamics during true microgravity and introduces the FDI as a sensitive and easily implementable metric for evaluating venous flow. These findings demonstrate the feasibility and physiological relevance of graded LBNP during parabolic flight and establish a methodological foundation for future multi-subject studies aimed at optimizing individualized countermeasures for long-duration spaceflight.

REFERENCES

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