ACUTE DOSE-RESPONSE OF THE INTERNAL JUGULAR VEIN TO GRADED HEAD UP AND HEAD DOWN TILT

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INTRODUCTION: Microgravity induced cephalad fluid shift has recently been associated with altered jugular venous flow, including flow stasis and reversal. On long-duration missions, it has been hypothesized that this altered flow could lead to increased thrombogenicity, with a resultant elevated embolic risk. The aim of this study is to generate gravitational dose-response curves of the common carotid artery (CCA) and the internal jugular vein (IJV) hemodynamic responses using a tilt paradigm. This investigation will improve the understanding of the vascular response to altered-gravity and provide a baseline that can be used to compare the magnitude of these changes during spaceflight, as well as the efficacy of measures to counteract altered blood flow in the neck.

METHODS: Twelve male subjects (age 27.2±2.7 years, height 179.0±8.3 cm, weight 84.7±18.7 kg) were subjected to graded tilt from 45° head-up through to 45° head-down in 15° increments, in both supine (face up) and prone (face down) positions. Ultrasonography of the left and right CCAs and IJVs, and jugular venous pressures (P_{IJV}) were recorded at each tilt angle.

RESULTS: The cross-sectional area of the CCA, A_{CCA}, did not significantly change with tilt (p=0.262) or position (p=0.361), and there was no significant difference between the left and right sides (p=0.849). In contrast, IJV cross-sectional area, A_{IJV}, and pressure, P_{IJV}, were both highly dependent on tilt in a non-linear fashion (p<0.001 in both). Further, the right IJV was significantly larger than the left IJV (p<0.001) and expanded more rapidly with tilt than its left counterpart. P_{IJV} was equivalent in the left and right sides (p=0.775) but was significantly higher in the prone position (p<0.001).

DISCUSSION: Gravitational dose-response models quantifying the expansion and increase in pressure of the IJV in tilt were constructed using generalized additive mixed-effects models. These dose-response curves were compared with existing data from parabolic flight and spaceflight studies, showing good agreement on an acute timescale. The quantification of fluid shift in altered-gravity informs the understanding of the pathogenesis of spaceflight-induced venous thromboembolic risk. Future investigations will collect similar data in female subjects and will compare these dose-response curves to interventions focused on reducing cephalad fluid shift, such as lower body negative pressure and short-radius centrifugation.

LEARNING OBJECTIVES

1. The audience will learn about quantitative changes in the common carotid artery and internal jugular veins due to altered-gravity environments.

2. The audience will learn about the relationship between spaceflight induced cephalad fluid shift and increased risk of venous thromboembolism events.

QUESTIONS

1. The common carotid artery and internal jugular vein both expand significantly in head-down tilt
    a. True
    b. False
2. Which of the following are risk factors for thrombosis?
    a. Intravasucular vessel wall damage
    b. Stasis of flow
    c. Presence of a hypercoagulable state
    d. All of the above
3. The expansion of the internal jugular vein in head-down tilt is highly non-linear
    a. True
    b. False