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WHY DOES CENTRAL VENOUS PRESSURE GO BELOW SUPINE LEVELS IN WEIGHTLESSNESS?

Abstract

A common explanation for why central venous pressure (CVP) falls below supine levels in space is that intrathoracic pressure falls dramatically in weightlessness. This pressure drop is then transmitted to the intrathoracic vasculature creating the paradoxical drop in CVP with simultaneous rise in cardiac output. This explanation is based on esophageal pressure measurements via esophageal balloon, taken before and during weightlessness exposure on parabolic flights with the subject in the supine position. Esophageal pressure is commonly used as a surrogate for intrathoracic pressure by measuring pressure with a balloon in the lower 1/3 of the esophagus, just posterior to the heart.

However, while upright esophageal balloon measurements may accurately reflect intrathoracic pressure, supine measurements do not. In the supine position the balloon is compressed by the heart and other tissues that lie in front of the esophagus, artificially increasing measured intrathoracic pressure. Without the force of gravity, heart and tissue pressures are removed from the balloon, leading to an exaggerated drop in the balloon pressure. When esophageal pressure is measured in upright subjects, intrathoracic pressure increases slightly in microgravity. Direct measures of intrathoracic pressure show that supine and upright intrathoracic pressures differ only slightly. Therefore, if intrathoracic pressure were falling dramatically in weightlessness, this should be seen for both the upright and supine cases. The high balloon pressures supine compared to upright suggest there are unaccounted for tissue pressures in the supine case. Supporting this notion, studies investigating postural effects on esophageal measurements reflect higher esophageal pressures in supine compared to upright.

An alternative explanation for the reduced CVP in weightlessness is that the removal of gravitational forces removes both hydrostatic forces within vessels and the pressures produced by the weight of tissues on the outside of blood vessels. This serves to increase the compliance of the venous system thereby allowing the venous blood to be contained in the same vascular space at a lower pressure. This overall reduction in venous pressure would explain why not just CVP but also peripheral venous pressure is reduced in weightlessness. Similarly, cardiac compliance is also improved by the removal of tissue weight. Increased left ventricular compliance in the microgravity environment would also lead to increases in cardiac output by increasing ventricular filling volume for the same end diastolic pressure.