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CHANGES IN INTRACRANIAL PRESSURE AND OPTIC NERVE SHEATH DIAMETER WITH INCREASING CEPHALAD FLUID SHIFTS IN A PORCINE MODEL

Abstract

Purpose: Non-traumatic, non-hydrocephalic increases in intracranial pressure (ICP) are often difficult to diagnose and may underlie space-related visual changes. We have designed a porcine model to study potential physiologic risk factors (like cephalad fluid shifts) and evaluate deployable technologies to detect elevated ICP. Transocular ultrasound is a non-invasive method used during space flight to assist in detection of potential ICP increases by measured increases in optic nerve sheath diameter (ONSD). Though useful in traumatic brain injury and hydrocephalus, the utility in conditions of cephalad fluid shifts from increased cephalad venous fluid pressure (CVIP) is unknown. This study looks at the utility of a porcine animal model to mimic changes in ICP and ONSD with increases in CVIP.

Methodology: Using juvenile piglets (N=10) measurements of ICP, internal jugular pressure (IJP), and external jugular pressure (EJP) were made at increasing levels of superior vena caval (SVC) pressure. To elevate and control SVC pressure, a Fogarty occlusion catheter was inserted via the right EJ into the SVC and inflated to achieve IJP pressures for 1 hour of 10mmHg, 20mmHg, and 40mm Hg. ONSD of the right eye was measured by ultrasound at each pressure level.

Results: There was a significant linear correlation between increasing IJP and ICP (slope: 1.04 +/- 0.01, $r = 0.80$, $p < 0.0001$). The mean difference in ICP from increasing IJP of 10 to 20 mmHg was 9.64 3.80 ($p = 0.04$) and from 20 to 40 mmHg was 19.26 +/- 6.85 ($p = 0.05$). The EJP and ICP were also similarly correlated (slope: 1.56 +/- 0.02, $r = 0.81$, $p < 0.0001$). With changing CVIP, the increasing ICP and ONSD were also well correlated (slope: 0.10 +/- 0.01, $r = 0.7458$, $p < 0.0001$). The mean difference in ONSD between ICP of < 20 mmHg and > 20 mmHg was 1.44 +/- 0.19 mm ($p < 0.0001$).

Conclusions: Increases in CVIP result in increases in ICP that are well correlated with changes in ONSD. These changes are attributable to increases in cerebral blood volume and studies are underway to assess the impact of increased CVIP on cerebrovasular autoregulation. This model may also prove useful to study other non-invasive modalities for estimating ICP.