NONINVASIVE MEASUREMENT OF INTRACRANIAL PRESSURE AND CEREBRAL BLOOD FLOW AUTOREGULATION: A RHEOENCEPHALOGRAPHY STUDY

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It is known that microgravity increases intracranial pressure (ICP) and causes space flight-associated neuro-ocular syndrome (SANS) [1] damages cerebral blood flow (CBF AR), causing orthostatic intolerance, headache, and impaired neurocognitive performance in astronauts. The most likely mechanisms of spaceflight-induced increased ICP include a cephalad shift of body fluids, venous outflow obstruction, blood-brain barrier breakdown, and disruption to CSF flow [2]. However, a CBF increase was reported, too [3]. Invasive ICP measurement is out of reality during spaceflight. Rheoencephalography (REG) is a non-invasive method to study CBF and its AR [4]. Russians used REG in the 1970s on Salyut 4 [5] but did not measure CBF AR nor change in REG pulse wave morphology [6]. Related CBF studies use Transcranial Doppler (TCD) which is used to determine CBF in the middle cerebral artery. However, CBF AR is a function of arterioles [7], and is not measured. A recent clinical study demonstrated that REG pulse wave morphology shows identical alteration as ICP by reflecting decreased intracranial compliance caused by ICP elevation, increasing the 2nd pulse peak [8, 6]. One of the accepted models to study the effect of microgravity is the head-down tilt (HDT) test ([9]. The most advanced CBF AR status calculation (PRx) is used in clinical practice with ***invasive*** measurements of ICP and arterial pressure with the ICM+ program [10]. A study documented a good correlation between PRx and REGx [11].

In nineteen healthy volunteers (n=13 male; n=6 female) we recorded bifrontal REG derivations and arm bioimpedance pulses with a 200 Hz sampling rate. The challenge was a -15-degree HDT position for 17.62 (±2.39) minutes. Data were stored and processed offline. REGx was calculated by DataLyser (DL, an in-house developed) program. The P2 calculation will be integrated into DL in the future.

The dominant REG pulse wave morphological change was the 2nd peak amplitude increase or “shoulder formation” on the decreasing, (catacrotic) side of the pulse wave during the HDT position. The 2nd peak increased in 15 subjects (78 %); the “shoulder” formation on the catacrotic side was observed in 11 subjects (58%). With automated analysis REG P2 increase was significant for females (p=0.01) and significant for males (p=0.02). REGx in male and female group averages have similar trends during HDT: REGx decreased at the start of HDT, indicating the active status of CBF AR.

The morphological change of REG pulse wave during HDT position was identical to ICP waveform change during increased ICP, reflecting decreased intracranial compliance. Future correlation studies between ICP and REG can justify using REG in military aviation, space medicine, and neurocritical care. We demonstrated previously the correlation between the increase of REG pulse wave 2nd peak amplitude during the passive status of CBF AR [6] and here during HDT. We created and tested a program capable of detecting such a type of change automatically. Additionally, we successfully tested dry, reusable, REG/bioimpedance electrodes for space research without alcohol rubbing [12]. These electrodes can be held by head and armbands. REG measurement 1) can be done before or immediately after OCT and fundoscopy measurements to describe the cerebrovascular aspect of SANS; 2) REG can quantify the accelerated cerebrovascular aging during space travel; 3) The use of a miniaturized REG device (with modules of the DL program) on ISS is a cheap and practical, ***noninvasive*** measuring possibility.

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