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Quantification of Global Cerebrovascular Reactivity in the Principal Feeding Arteries of the Human Brain

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Abstract : Introduction Global cerebrovascular reactivity (CVR) mapping is a promising clinical assessment for stress-testing the brain using physiological challenges, such as CO_2, to elicit changes in perfusion. It enables real-time assessment of cerebrovascular integrity and health. Conventional imaging approaches solely use steady-state parameters, like cerebral blood flow (CBF), to evaluate the integrity of the resting parenchyma and can erroneously show a healthy brain at rest, despite the underlying pathogenesis in the presence of cerebrovascular disease. Conversely, coupling CO_2 inhalation with phase-contrast MRI neuroimaging interrogates the capacity of the vasculature to respond to changes under stress. It shows promise in providing prognostic value as a novel health marker to measure neurovascular function in disease and to detect early brain vasculature dysfunction. Objective This exploratory study was established to:(a) quantify the CBF response to CO_2 in hypocapnia and hypercapnia,(b) evaluate disparities in CVR between internal carotid (ICA) and vertebral artery (VA), and (c) assess sex-specific variation in CVR. Methodology Phase-contrast MRI was employed to measure the cerebrovascular reactivity to CO_2 (±10 mmHg). The respiratory interventions were presented using the prospectively end-tidal targeting RespirActTM Gen3 system. Post-processing and statistical analysis were conducted. Results In 9 young, healthy subjects, the CBF increased from hypocapnia to hypercapnia in all vessels (4.21±0.76 to 7.20±1.83 mL/sec in ICA, 1.36±0.55 to 2.33±1.31 mL/sec in VA, $p < 0.05$). The CVR was quantitatively higher in ICA than VA (slope of linear regression: 0.23 vs. 0.07 mL/sec/mmHg, $p < 0.05$). No statistically significant effect was observed in CVR between male and female (0.25 vs 0.20 mL/sec/mmHg in ICA, 0.09 vs 0.11 mL/sec/mmHg in VA, $p > 0.05$). Conclusions The principal finding in this investigation validated the modulation of CBF by CO_2. Moreover, it has indicated that regional heterogeneity in hemodynamic response exists in the brain. This study provides scope to standardize the quantification of CVR prior to its clinical translation.

Keywords : cerebrovascular disease, neuroimaging, phase contrast MRI, cerebrovascular reactivity, carbon dioxide
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