DEVELOPMENTAL TRAJECTORIES OF GLOBAL OEF, CBF, CMRO2 USING SUSCEPTIBILITY-BASED OXIMETRY, PHASE CONTRAST MRI AND ASL

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PURPOSE: Global values of oxygen extraction fraction (OEF), cerebral blood flow (CBF) and cerebral metabolic rate of oxygen (CMRO2) can serve as important surrogate markers for brain function. To date, however, scarce research has examined these parameters in typically developing children due to the invasive nature of existing techniques such as jugular venous oximetry and Positron Emission Tomography (PET). Recently, noninvasive and quantitative MRI methods for in vivo measurements of global OEF, CBF and CMRO2 have been developed (1). The present study seeks to explore the developmental trajectories of OEF, CBF and CMRO2 by applying these novel MRI methods in typically developing children and adolescents aged 7 to 17 years.

METHODS: MRI data was collected on 47 (23M/24F) participants 7-17 years of age on a Siemens 3T TIM Trio scanner. Phase-contrast (PC)-MRI (VENC = 80cm/sec; TE/TR=5.23/18ms; FOV=200x200mm2; matrix=192x192; Slice Thickness=5mm) was acquired at the level of the mouth orifice (between C1 and C2 vertebrae) to quantify mean flow velocities in internal carotid and vertebral arteries. Total cerebral blood flow volume (CBFV) was calculated as the product of flow velocities and cross-sectional areas of the major arteries, and CBF by dividing CBFV with the brain volume estimated from T1 weighted structural MRI after skull striping. Global CBF estimated using PC-MRI decreased with age (R = -0.52, p = 1.8E-4, Fig. 1D). The strong correlation between global CBF estimated using pCASL (R = -0.61, p = 4.6E-6, Fig. 1B), which was also positively correlated with global CMRO2 (R = 0.64, p = 1.4E-6, Fig. 1C). As a result, global CMRO2 decreased with age (R = -0.52, p = 1.8E-4, Fig. 1D). The above developmental trends were similarly observed for male and female children.

DISCUSSION: Past brain physiology and metabolism studies using nuclear medicine approaches have shown that CBF and CMR of glucose peak in toddlers (~5yr old) and then decrease with age in children and adolescents (2, 3). The observed developmental trajectories of CBF and CMRO2 are in excellent agreement with existing literature. The strong correlation between global CBF estimated using PC MRI and pCASL adds further support to the validity of the proposed methods.

CONCLUSION: The present study applied PC MRI, blood oximetry and ASL to explore the developmental trajectories of global OEF, CBF and CMRO2 in excellent agreement with literature. The noninvasive and quantitative nature of these novel MRI methods may open the door to measure developmental changes of brain function and metabolism across lifespan as well as in various neurodevelopmental disorders.