HUMAN BRAIN TEMPERATURE REGULATION AND OXIDATIVE METABOLISM DURING FUNCTIONAL VISUAL STIMULATION

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A fundamental discovery of modern human brain imaging with positron emission tomography (PET) that the blood flow to activated regions of the normal human brain increases substantially more than the oxygen consumption (Fox & Raichle, 1986) has lead to a broad discussion in the literature concerning possible mechanisms responsible for this phenomenon. Presently no consensus exists. It is well known that oxygen delivery is not the only function of systemic circulation. Additional roles include delivery of nutrients and other required substances to the tissue, waste removal, and temperature regulation. Among these other functions, the role of regional cerebral blood flow (rCBF) in local brain temperature regulation has received scant attention. Here a theoretical analysis is presented supported by empirical data obtained from humans with functional magnetic resonance (fMR) suggesting that increase in rCBF during functional stimulation can cause local changes in brain temperature and subsequent changes in oxygen consumption. Major factors contributing to temperature regulation during functional stimulation are changes in the oxygen consumption, changes in the temperature of incoming arterial blood and heat exchange between activated and surrounding tissue. The water proton magnetic resonance (MR) frequency temperature-shift of -0.01ppm/°C was employed to monitor local brain temperature changes in human volunteers during functional activation. The MR data were collected on a 1.5 tesla Siemens Magnetom Vision scanner using a single voxel localization technique that allows estimation of both water signal intensity and signal frequency (Yablonskiy *et al.*, 2000). A typical voxel size was 10 ml and experimental repetition period was 2 sec. The functional activation paradigm included 4 min of rest, followed by 4 min of visual cortex stimulation using GRASS goggles flashing at 8 Hz, followed by a final 4 min. of rest. MR signal intensity and signal frequency (temperature) both change during functional activation. Local brain temperature decreases on average by about 0.2°C during activation, however, individual variations up to ±1°C have also been observed. An important feature of all data is a strong correlation (R=0.94) between the slope that characterizes the change in signal intensity with time and the slope that characterizes the change of signal frequency with time during the activation period. This effect offers additional evidence of brain temperature changes during functional activation. Indeed, change in brain temperature results in change in the rate of chemical reactions, hence tissue metabolism, hence venous blood oxygen saturation, hence MR signal intensity. A MR microcirculation model (Yablonskiy *et al.*, 1994), allows estimation from this data of a mean change in metabolic reaction rate on the order of 8% per 1°C, which is in agreement with published data (Swan, 1974).

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