Quantification of Cerebral Blood Volume using Breath Hold in Rat

Seon Joo Kwon[1], Woo Hyun Shim[1], Bharat B Biswal[2], and Young Ro Kim[1]
[1]Radiology, MGH, Charlestown, MA, United States, [2]Radiology, New Jersey Medical School, Newark, NJ, United States

INTRODUCTION Signal changes created by the altered vascular magnetic susceptibility have been applied frequently for quantifying the cerebral blood volume (CBV) using magnetic resonance imaging (MRI). The typical CBV quantification strategy has been based upon the systemic administration of MR contrast agents. MRI signal changes due to the transiting bolus of MR contrast agents through intravascular space (dynamic susceptibility contrast imaging: DSC) have been analyzed for obtaining multiple vascular parameters such as CBV and mean transit time. In the current study, we propose to use breath hold (BH) and the associated tissue MRI signal changes to bypass the use of MR contrast agents and to enable the measurement repeatability. Specifically, we first calculated the relative CBV in normal rat brains by measuring the total MR signal changes (area under curve) induced by the bolus injection of Gd-DTPA and compared the results with those obtained from various breath hold epochs for validating the CBV measurement accuracy of the breath hold technique.

MATERIALS & METHODS: Sprague Dawley rats (n=6) weighing ~300g were prepared with intravenous cannulations of femoral veins for the bolus injection of contrast agent (Gd-DTPA) and continuous infusion of alpha-chloralose (~30 mg/kg/h) and pencuronium (~1.25 mg/kg/h) as an anesthetic agent. Mechanical ventilator was used to execute the breath hold protocol. DSC MRI was acquired using gradient echo planar imaging (GE EPI) with TR/TE=300/12.89 ms, matrix=80x80, FOV=2.5cm, during Gd-DTPA bolus injection, and the BH MRI was performed with TR/TE=1000/12.89 ms during three breath hold epochs (10, 20, 30 sec). For the analysis, we performed the voxelwise correlation between CBV values obtained from two techniques.

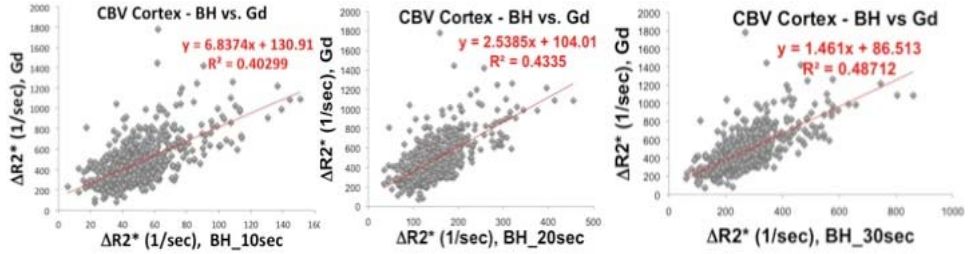
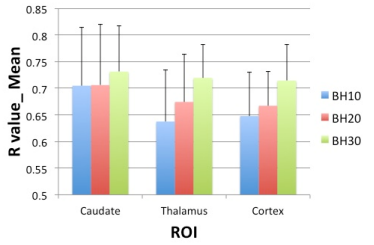
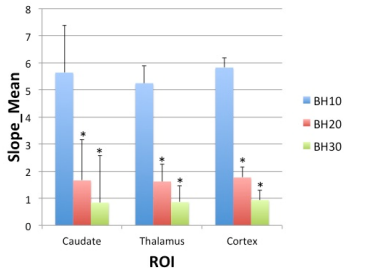


Fig 1. ΔR2* (area under curve) comparison between DSC and BH techniques for different BH periods (10, 20, 30 sec).

RESULTS & DISCUSSION: The current work introduces a novel *in vivo* method for quantifying the relative CBV using the changes in magnetic susceptibility of blood during breath hold. We compared the voxelwise CBV values acquired from the DSC and BH methods and validated that they are highly correlated (Fig. 1). As results of the linear regression between CBV values calculated from two methods, we found no significant regional dependence in the fitting parameters. However, the R values increased with increasing the BH period and the dependence (slope) also changed significantly with the BH period. Therefore, a longer breath hold period would result in higher measurement accuracy and precision. The BH method is advantageous over other conventional methods (e.g., DSC and steady state method using intravascular contrast agents) in terms of (1) no requirement of contrast agent injection and (2) possibility of repeated measurements. We posit that the BH method will bring forth the clinical application of CBV quantification in the patient population who are contraindicated with injection of contrast agent.



(a)



(b)

Fig 2. Regional dependence and correlation between CBV values calculated from the DCS and BH methods for various BH periods (10, 20 , 30 sec) - slope (a) and R value (b).