Comparison of breathhold versus PACE triggering in renal BOLD MRI

Maryam Seif[1], Chris Boesch[1], and Peter Vermathen[1]
[1]*Depts Clinical Research and Radiology, University of Bern, Bern, Bern, Switzerland*

Background: The estimation of renal tissue oxygenation can play an important role in investigating renal dysfunctions[1]. Blood oxygenation level dependent (BOLD) MRI is a non-invasive approach that can monitor renal pO2 by measuring R2* (= 1 / T2*) [2]. Previous studies have shown the potential of BOLD to investigate healthy and transplanted kidney[1-8]. To minimize motion artifacts caused by respiratory motion, BOLD kidney MRI has been performed in breath hold, which may not be feasible for patients[6]. At least in those patients that cannot hold their breath long enough, respiratory triggered renal BOLD measurement would be beneficial and facilitate the abdominal measurements. **Purpose**: The current study therefore is aimed at evaluating the feasibility of the Prospective Acquisition CorrEction (PACE) triggered renal BOLD MRI in comparison with breath-hold (BH) BOLD MRI.

Methods: The study was approved by the local ethics committee and written informed consent was obtained from all subjects. Eleven healthy volunteers (6 female, 5 male, age =29.1±9.5y) without a history of chronic diseases underwent a multiple-gradient recalled echo (mGRE) BOLD sequence within a single breath-hold as well as with the PACE triggering technique on a clinical 3T MRI scanner (Trio, Siemens Erlangen Germany). The BH-BOLD sequence was separately performed 3 times to acquire 3 coronal slice positions with TR of 65 msec. Twelve T2* weighted images corresponding to 12 echoes were obtained within one 17 second breath-hold for each slice position. The PACE-BOLD sequence was performed with 5 coronal slice positions. Average duration for the PACE-BOLD was 5.7±1.5 min. The remaining parameters for breath-hold and PACE triggered BOLD sequences were as follows: 12 TEs of 6-52.30 msec, Flip Angle=30^0, BW= 330 Hz/Px, FOV=400 x 400 mm^2, Matrix 256×256, slice thickness of 5 mm. **Processing:** In order to further reduce potential respiratory motion artifacts, registration of individual images was performed using an in-house developed image co-registration software based on the method proposed by H. Lu et al.[9]. At least six regions of interest (ROIs) were placed on 3 slices for each subject in medulla and cortex on BH-BOLD images with individual ROI sizes of 90±17 and 77±13 pixels, respectively as well as on PACE-BOLD scans with individual ROI sizes of 100±16 and 76±14 pixels, respectively. Two subjects were excluded from the analysis, due to the poor visual quality of PACE triggered scans and because significantly fewer ROIs could be analyzed than on the corresponding BH-BOLD images. The R2* maps were generated by fitting the signal intensity vs. TE data to a linear function.

Results: The T_2* weighted images and R2* maps acquired in BH-BOLD visually demonstrated less distortion, compared to the PACE-BOLD MRI for most subjects (Fig.1). Table 1 shows that the mean R2* values of medulla and cortex were similar for breath-hold and PACE-BOLD scans. Mean R2* in medulla and cortex was highly significantly different in both breath-hold and PACE-BOLD measurements (P<0.001). However, cortical R2* was slightly, but significantly higher in PACE-BOLD than in BH-BOLD, while they were very similar in medulla. There was a significant correlation between Breath-hold and PACE-BOLD of medullary and cortical R2* values (Medullary R^2 = 0.69, P=0.005 and Cortical R^2 = 0.61, P=0.01, Fig.2).

Discussions & Conclusions: Our evaluations of R2* demonstrate that PACE triggering for BOLD measurements is clearly feasible in renal investigations and yields comparable results to the BH-BOLD approach. In contrast to the visual differences between BH- & PACE-BOLD images, the quantitative analysis of R2* yielded similar results for both methods, despite the slightly higher cortical R2* in PACE-BOLD. R2* values of both methods are somewhat smaller than previously reported, however, substantially different values have also been reported before[8], possibly demonstrating the sensitivity of BOLD MRI to scan parameters and shimming status.
In conclusion, the small difference of means and the correlations between BH-BOLD and PACE-BOLD R2* values suggest that PACE-BOLD MRI can facilitate renal measurements on elderly and diseased subjects, who may have problems holding their breath.

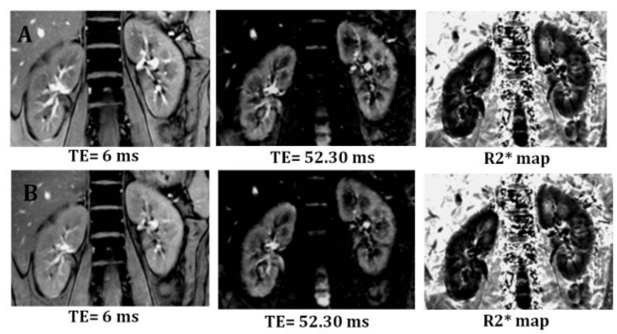

Fig. 1: (A) BH-BOLD images, **(B)** PACE BOLD images from the shortest & longest two echo times and corresponding R2* maps.

	Medullary mean R2* (s^{-1})	Cortical mean R2*(S^{-1})
BH BOLD MRI	23.6 ±2.0	17.9±1.1
PACE BOLD MRI	23.4±1.1	18.9±1.4
t-test	p=0.5	p=0.01

Table 1: Comparison of mean R2* between BH and PACE BOLD

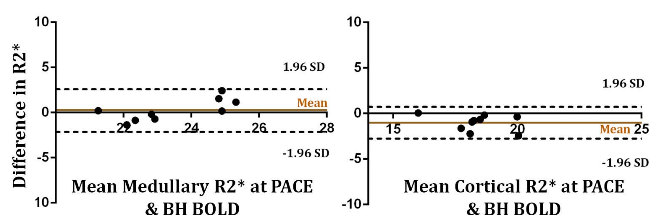

Fig . 2: Bland-Altman plots of the medullary and cortical R2* at PACE & BH BOLD (medullary R^2 = 0.69, P=0.005 & cortical R^2 = 0.61, P=0.01)

1. Prasad PV. et al Nephron Clin Pract. 2006; 103(2):58-65 **2. Prasad PV.** et al. Circulation 1996; 94:3271–75, **3. Thoeny HC**. et al. Radiol. 2006; 241:812-21, **4. Thoeny HC. et al.** Radiol. 2008;247:754-61, **5. Vermathen P.** et al. JMRI 2012; 35:1133–38, **6. Sadowski E. A.** et al. Radiol. 2005; 236:911–19, **7. Ding Y.** et al. JMRI 2013; 38:1230–36, **8. Tumkur S.** Invest. Radiol. 2006; 41(2): 181–84, **9. Lu H.** et al. ISBI. 2010;372-75