# Breath Holding Has No Effect on BOLD Signal in the Kidney

Marla Shaver[1], and Michael Noseworthy[2,3]

*[1]School of Biomedical Engineering, McMaster University, Hamilton, Ontario, Canada, [2]School of Biomedical Engineering, Electrical and Computer Engineering, McMaster University, Hamilton, Ontario, Canada, [3]Imaging Research Centre, St. Joseph's Healthcare, Hamilton, Ontario, Canada*

**Introduction**: Abnormal oxygenation can be observed in many renal diseases, and BOLD MRI has been shown to be a reasonable option for evaluating renal oxygenation **[1]**. Current studies implement breath holding to obtain motion-free kidney images for T2* or R2* mapping **[2]**. Breath holding can potentially affect blood $pCO_2$ and hence microvascular tone. In this study we used real-time BOLD imaging to investigate whether breath holding can play a significant role in modulating kidney microvasculature.

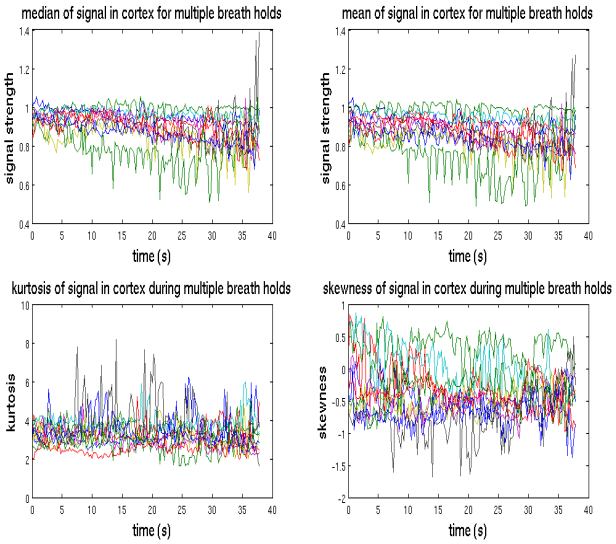


**Figure 1**: Sample plots from a single subject, over multiple breath holds (superimposed as different colours) showing the evolution of cortex ROI BOLD signal mean, median, skewness and kurtosis. Breath holding did not produce any significant signal changes.

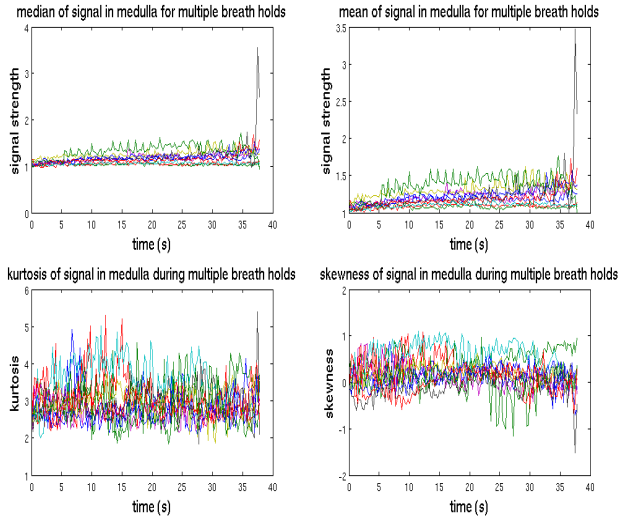


**Figure 2**: Sample plots from a single subject, over multiple breath holds (superimposed as different colours) showing the evolution of medulla ROI BOLD signal mean, median, skewness and kurtosis. Breath holding did not produce any significant signal changes.

**Materials and Methods**: In a study approved by our research ethics board, the kidneys of healthy subjects (n=6) were imaged using a T2* weighted (BOLD) GRE EPI sequence (TR/TE=250/35ms, flip=70°, FOV=30cm 96x96 matrix, 3 slices 5mm thick, 0mm skip, oblique-coronal plane, 2400 temporal points, 10 minutes total time). The acquisition plane was prescribed from a sagittal multiphase FIESTA to select along the longitudinal axis of the right kidney, the direction of motion during breathing. All scans were done using a GE Healthcare 3T HD Signa MRI and 8 channel torso phased array coil. Respiratory data was collected concurrently with BOLD scanning using the MRI scanner respiratory bellows. During BOLD scanning, subjects were instructed to hold their breath for as long as possible, breathe when needed, and repeat this for the duration of the 10 minute scan. After data collection, the images were processed with a template matching algorithm previously used for kidney analysis **[3]**. Regions of interest (ROI) were selected for the renal medulla and renal cortex using AFNI **[4]**, and this data was exported to MATAB (The Mathworks, Natick MA)**.** Only data obtained during breath holding was used for analysis. These temporal segments were selected in MATLAB, using data obtained with the respiratory bellows, to determine the duration of the shortest breath hold and their start times. Following normalization to t=0, mean, median, skewness and kurtosis were calculated for each ROI, over time, during each breath hold. We hypothesized BOLD would decrease with length of breath holding.

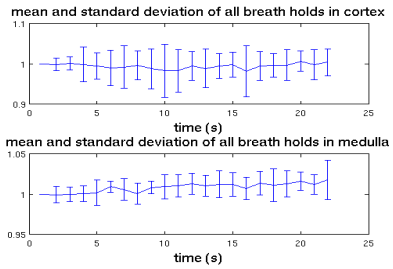


**Figure 3**: Plots showing mean and standard deviation of all breath holds from all subjects normalized to t=0 for renal cortex and medulla ROI during breath holding. No trends exist.

**Results**: No trends could be identified in the BOLD signal intensity during breath holding in the cortex (**Fig. 1**) or medulla (**Fig. 2**). Averaging of all breath holds for all subjects did not show any trends (**Fig. 3**).

**Conclusion**: Because no trends were present in the BOLD data obtained from the kidney during breath holding, it is evident that breath holding has no effect on kidney BOLD signal. As a result, utilizing breath holds for data acquisition in renal BOLD experiments should not affect the results of these studies.

**References**:

**[1]** Heyman S, *et. al*. (2008) *Am J Nephrol.* 28:998-1006. **[2]** Notohamiprodjo M, *et. al*. (2010) *Eur J Radiol*. 76:337-347. **[3]** Boyd BJ. (2009) *ESMRMB* 26:678. **[4]** Cox RW. (1996) *Comp Biomed Res.* 29:162-173.