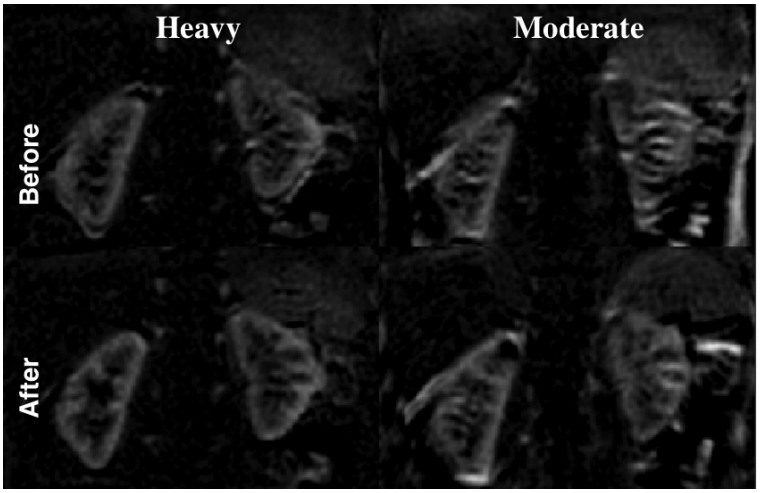
Retrospective strategy for reducing respiratory motion artifacts in renal perfusion imaging with arterial spin labeling

Arnaud Guidon[1], Weiying Dai[2], and David C. Alsop[2]
[1]GE Healthcare Global MR Applications and Workflow, Boston, MA, United States, [2]Department of Radiology, Beth Israel Deaconess Medical Center, Boston, MA, United States

Introduction Arterial Spin Labeling (ASL) is particularly well-suited for the clinical evaluation of patients with renal insufficiency for whom the risk of gadolinium-based contrast administration is undesirable. However, ASL measurements in the body are prone to physiological effects such as cardiac pulsation and abdominal displacements during respiration, which must be corrected prior to subtraction of tag and control images to avoid misregistration errors. As previously shown, a relatively robust strategy consists of combining timed breathing with a background suppression scheme **[1]**. However, the efficiency of this technique heavily hinges on a patient's ability to actively follow breathing instructions, which may not always be practical. Another free-breathing renal imaging scheme was evaluated in **[3]** using navigators placed immediately after the imaging module in an attempt to retrospectively reject misaligned acquisitions. However, this method is incompatible with background suppression (BS) and prone to significant labeling inaccuracies in patients with irregular breathing patterns. Alternatively, retrospective rigid-body motion correction techniques have been shown to work relatively well **[2]** although their combination with a background suppression scheme has not yet been investigated. In this study, we propose an alternative approach allowing background suppressed free-breathing renal perfusion pseudo-continuous ASL (PCASL) imaging which leverages retrospective elastic registration of individual tag and control images. Finally, we report on its efficacy for different levels of background suppression.

Methods A healthy volunteer (male, 35y.o) was scanned on a 1.5T scanner using a 12-channel body receiver-array for reception, the body-coil for transmission, and the product SSFSE sequence modified with a pseudo-continuous ASL (PCASL) preparation, for image acquisition with a 128x128 matrix, partial-Fourier of 9/16 in the phase encoding direction, a field of view of 40-cm, a slice thickness of 10mm and TR/TE=6000ms/42ms. The ASL imaging slice was positioned to include a cross-section of both kidneys. The slice was carefully prescribed such that the entireties of both kidneys were inferior to the labeling plane of the ASL magnetization preparation. Two successive experiments were performed with decreasing levels of background suppression whereby only 5% and 20% of background signal were respectively preserved. 26 control and tagged images were acquired for each scan. The volunteer was instructed to breathe freely during both experiments. Images were coregistered using the first image of each series as a reference. A non-linear multi-resolution registration algorithm was used as implemented in a freely available standalone third-party software (http://elastix.isi.uu.nl) and using a custom parameter file as input **[4]**.



Results Fig. 1 shows the perfusion images computed before and after registration for the two increasing levels of background suppression. As expected, retrospective elastic registration was able to mitigate gross motion artifacts caused by respiratory motion. It can be observed that the correction performed significantly better when heavy background suppression was applied. Due to the presence of high-signal anatomical features around the livers and intestinal tube, the algorithm did not perform as well when moderate background suppression was applied.

Fig1 Perfusion maps before and after registration for heavy and moderate BS.

Conclusion Our results demonstrate that a carefully tailored background suppression scheme may be combined with retrospective elastic image registration to allow free breathing renal perfusion imaging. We anticipate that this very convenient protocol will prove especially useful in clinical populations at risk of kidney failure for whom gadolinium-based contrast administration is proscribed. Alleviating the need for breath-holding should also help improve patient comfort.

References 1. Robson et al. 2009.. MRM 61, 1374–1387. 2. Gardener et al. 2010. MRM 63, 1627–1636 3. Tan et al., 2013. MRM DOI 10.1002/mrm.24692 4. Klein et al. IEEE TMI, vol. 29, no. 1, pp. 196 - 205, January 2010