Are Respiratory Triggered Diffusion Weighted Acquisitions of the Liver Effective at Eliminating Respiratory Motion?

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Purpose:

Diffusion weighted imaging (DWI) is currently used for detection and characterization of lesions in the abdomen, and assessment of treatment response. Apparent diffusion coefficient (ADC) values can be quantified from diffusion signal decay on DWI images obtained at the same anatomic levels with different b-values. Solid lesions show restricted diffusion and lower ADC values, where as cystic lesions show higher ADC values since water diffusion is less restricted. Accurate ADC calculation depend on optimal fitting of signal data so multiple data points at different b-values are typically acquired for abdominal DWI leading to relatively long acquisitions (i.e. several minutes). These acquisitions are thus vulnerable to anatomic misregistration due to respiratory motion. Different respiratory compensation methods are used to address this problem. While navigator-based approaches provide excellent anatomic co-registration they are generally inefficient and result in prohibited long acquisition times. Respiratory-triggered (RT) DWI acquisitions are most commonly used in the abdomen because they provide superior reproducibility than that of free-breathing techniques while maintaining total acquisition times within practical constrains for most clinical practices [1-4]. Our goal was to assess the efficiency of RT-DWI acquisitions to eliminate anatomic misregistations caused by breathing motion.

Methods:

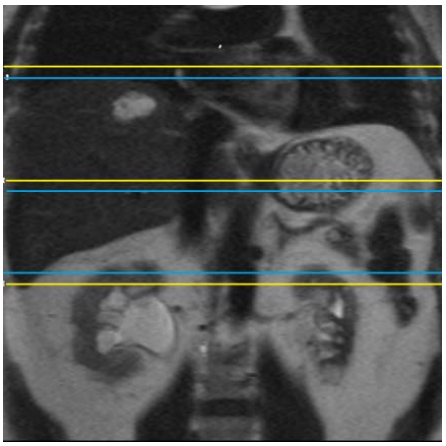
This was an IRB-approved, HIPAA-compliant, retrospective review of the abdominal MRI examinations performed between Nov, 2011 to Aug, 2012 in 4 of our clinical scanners: 1.5T and 3T Philips Achieva, 1.5T General Electric (GE) Optima and 1.5T GE Signa. Our clinical protocol for abdominal imaging includes an axial respiratory-triggered DWI spin-echo echo planar (SE-EPI) acquisition (TR=1861-10909, TE=73-84 Slice thickness=5.18-7mm, matrix= 120*120-256*256). These are acquired with 4 different b values (0,50,400 and 800 s/mm^2) on the 1.5T and 3T Philips platforms, and variable number of b values on the GE scanners: 2 b values (0,800 s/mm^2) on the 1.5T Signa and 2 (0,800 s/mm^2), 3 (50, 400, 800 s/mm^2), or 4 to 0,50,400,800 s/mm^2) b-values on the 1.5T Optima. For each patient's MRI, each available DWI dataset with different b-values were reviewed by a single reviewer to identify four different anatomical locations: 1) liver dome; 2) right portal vein (RPV); 3) inferior liver tip; and 4) and right kidney superior pole. Images at each level for these anatomic landmarks were then cross-referenced to the coronal T2-weighted image from the same study on our clinical PACS workstation. Horizontal lines were drawn on the coronal T2 image to mark the cross-referenced positions for each axial diffusion weighted image. The location of the *b0* image on the coronal slice served as the reference. Any misregistration for the rest of the axial diffusion weighted images with different b values for the same anatomic landmark in relation to this reference were tabulated in mm (positive measure for slices located above the reference and negative for slices located below the reference). The number of misregistered slices relative to the b=0 image for each anatomic landmark were tabulated. A Chi-square test was performed to assess the effect of MRI platform on respiratory misregistration.

Results:

A total of 81 MRI examinations were included in this study: 19 performed on 1.5T Philips Achieva, 21 on 3T Philips Achieva, 20 on 1.5 GE Optima and 21 on 1.5T GE Signa. Anatomic misregistration was noted in 60/81 (74%) MRI examinations. Overall, MRI examinations had zero (26%), one (42%), two (30%), and three (1%) misregistered slices combining each of the 4 anatomic landmarks. Anatomic misregistration occurred more often at the inferior liver tip (n=34, 39%) and less frequently at the level of the liver dome (n=13, 15%)(p value = 0.0129). The median displacement of misregestered slices relative to the b=0 image was 7mm for all scanners. MRI exams acquired with more b values were more prone to have larger displacement ($p<0.0001$).

Conclusion:

Respiratory-triggering does not eliminate respiratory misregistration in DWI acquisitions of the abdomen. Anatomic misregistration among axial images acquired with different b-values is very common and substantial in clinical practice. Our results challenge the notion of using RT-DWI as a robust technique for lesion characterization or assessment of response to therapy in the abdomen. Further investigation is necessary to assess the impact of anatomic misregistration on ADC calculation in focal liver lesions.



Coronal T2W anatomic image in a patient with misregistration noted at 3/4 locations. The yellow line represents the location of the b0 image and the blue lines are the misregistered slices: b-50,400, and 800 at the liver dome, b-50 at the RPV and b-50,400,800 at the inferior liver tip.

1. Chandarana, H. and B. Taouli, European Journal of Radiology, 2010. **76**(3): p. 348-358.
2. Kwee, T.C., et al., Journal of Magnetic Resonance Imaging, 2008. **28**(5): p. 1141-1148.
3. Taouli, B., et al., Journal of Magnetic Resonance Imaging, 2009. **30**(3): p. 561-568.
4. Kartalis, N., et al., European Radiology, 2012. **22**(10): p. 2186-2192.