Pediatric Abdominal Navigated T1-weighted MRI

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Introduction: T1-weighted gradient echo and T2-weighted spin echo imaging are a routine component of pediatric abdominal MRI. Though respiratory-triggering and navigation are routinely used for T2-weighted and cardiovascular imaging, there has been less attention to mitigating motion artifacts in T1-weighted imaging. This is due in part to the ability of adults to breath-hold for the shorter T1 scans; however, nonsedated children often cannot comply with breath-holding instructions and a sedated children require a deeper degree of sedation for assisted suspended respiration with attendant risk and increased sedation recovery time. Moreover, there is no inherent "dead time" in 3D gradient-echo T1-weighted imaging during which to play navigator pulses, so navigation approaches must be designed to minimize the impact on scan efficiency and image contrast. Here, we explore navigation to decrease motion artifacts in pediatric T1-weighted abdominal imaging.

Methods: On a 1.5 T GE Signa system, an intermittent two-dimensional low flip angle cylindrical excitation pulse followed by a readout gradient was incorporated into our routine fat-suppressed 3D gradient echo sequence (LAVA). The navigator pulse is executed every 200 ms to track respiratory motion and based on the position of the diaphragm. Imaging data is only accepted during a narrow range of end-expiration. Then with IRB approval and informed consent/assent, 10 consecutive pediatric patients scheduled for abdominal MRI with contrast underwent the following protocol: immediate post-contrast suspended respiration (voluntary or by anesthesiologist) LAVA, followed by free-breathing T1 navigated LAVA, and then free-breathing routine (non-navigated) LAVA. All studies were performed with either an 8-channel cardiac coil or a 12-channel phased array body coil. Images were retrospectively independently scored by two pediatric radiologists for motion artifacts on a 4 point scale (0 – severe abdominal wall ghosts, blurred vessels; 1 – moderate ghosts detected, vessels mostly defined; 2 – a few ghosts detected, vessels sharply defined; 3 – no ghosts). A Wilcoxon rank-sum test was used to test the null hypothesis that there is no significant difference in scores between the different methods.

Results: The protocol was completed in all ten patients without complication. Mean motion artifact scores were 2.4 (reader 1) and 2.8 (reader 2) for suspended respiration, 1.5 (reader 1) and 2.0 (reader 2) for navigated free-breathing, and 0.5 (reader 1) and 0.7 (reader 2) for non-navigated free-breathing. Suspended respiration images had significantly better image quality than navigated free-breathing ($p = 0.004$ and $= 0.06$ for readers 1 and 2 respectively), whereas navigated free-breathing images had significantly better image quality than conventional free-breathing ($p = 0.001$ and $p = 0.007$ for readers 1 and 2 respectively). No saturation effects from the navigator pulse were detectable in any patient.

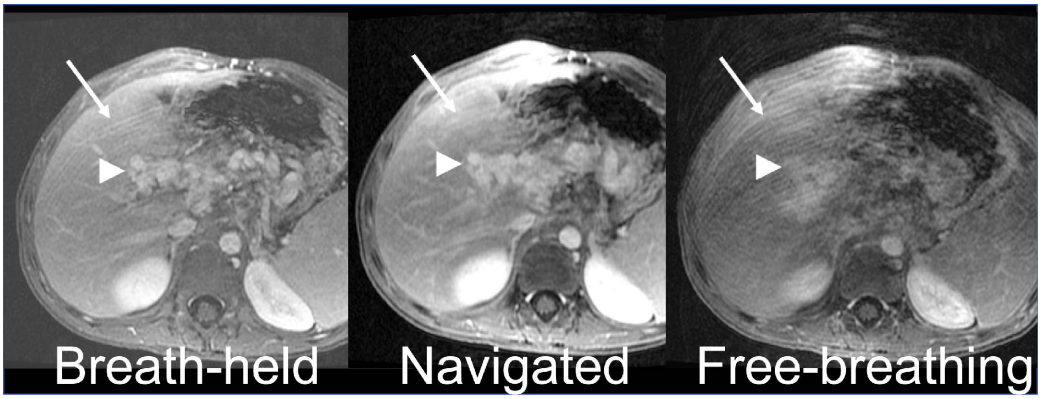

Figure 1. 6 year old male with liver disease. Breath-held acquisition was obtained immediately after a bolus of propofol was administered followed by gadolinium, and has residual ghosts since no paralytic agent was used (arrow). Ghosts are also present on navigated acquisition and more prominent with free-breathing acquisition. Note delineation of portal vein cavernous transformation (arrowhead), which is suboptimal with free-breathing acquisition.

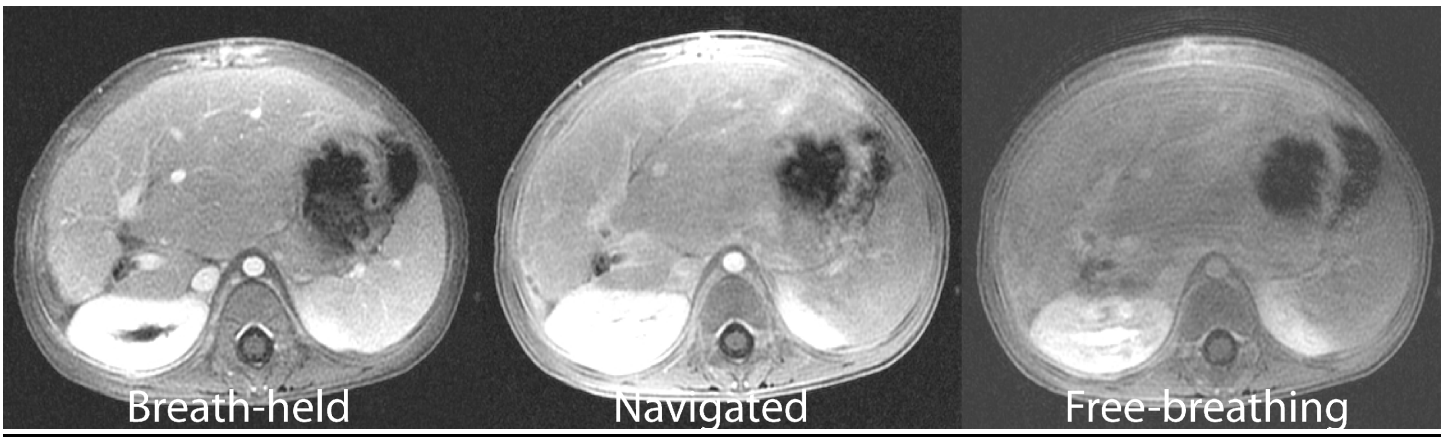

Figure 2. 2 year old male with history of hepatoblastoma. Despite right lobe resection, navigated acquisition has minimal motion artifacts.

Discussion: Respiratory motion significantly degrades image quality in pediatric MRI. Although much work has been done to address this issue for T2-weighted imaging, T1-weighted imaging has received less attention. This is due in part to the ability of adults to breath-hold for the shorter T1 scans, previously limiting the motivation of vendors to address this problem. However, children often cannot comply with breath-holding instructions and a deeper degree of sedation is required for assisted suspended respiration. We present a novel technique of T1 navigation and a pilot study suggests image quality is improved over free-breathing, but not over suspended respiration. Thus, this method may benefit children unable suspend respiration.