Abdominal Motion Control in Breath-hold MRI using Audiovisual Biofeedback

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Purpose: In body MRI, respiratory gating and breath-hold methods for respiratory motion-compensation are practically useful, but respiratory gating increases scan time and breath-hold requires the patient's full cooperation during the scan[1, 2]. For high signal-to-noise ratio (SNR) of images, multiple breath-hold acquisitions are required but it is not simple to keep the identical anatomic position during scans. The aim of this study is to develop a novel respiratory motion control system using audiovisual (AV) biofeedback combined with abdomen MRI and to demonstrate improved abdominal position reproducibility and reduced motion artifacts in breath-hold MRI.

Method and Materials: An AV biofeedback system has been developed to provide respiratory guidance during radiotherapy and medical imaging[3]. The real-time respiratory motion signals have been obtained using the real-time position management (RPM) system (Varian) consisting of an infrared camera and a marker block on the abdomen (see Fig. 1). In respiratory guidance during MR scans, the system has been combined with an MR compatible AV system such as a projector, a screen and headphones. The AV biofeedback system utilized (1) the external position information of the abdomen using the RPM system to guide a human subject for regular breathing and abdominal breath-hold position and (2) a single shot Fast Spin Echo (ssFSE) MR pulse sequence for abdomen imaging (14 slices on axial plane): TR/TE 1528/101 ms, FOV 380x304 mm^2, slice thickness 6 mm, and image matrix 448x224. The radiographer's verbal instructions were provided during a free breathing and AV biofeedback sessions. Two sequential measurements were acquired at maximum inhalation for both scenarios. The abdominal position control using the AV biofeedback within the MRI system has been tested in two separate studies.

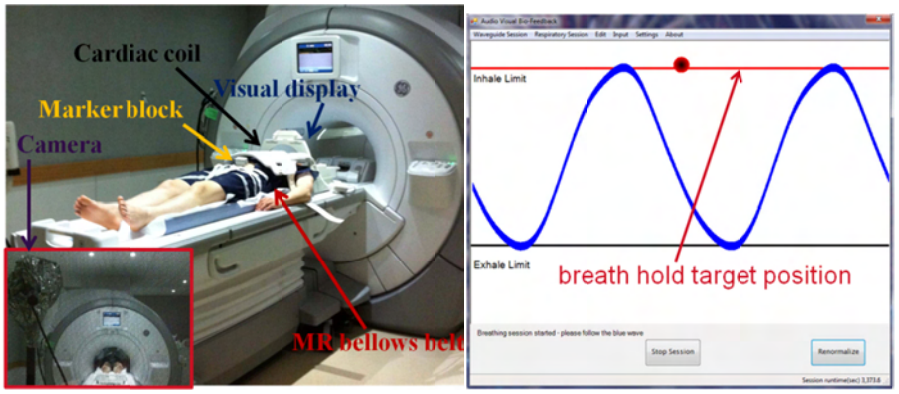

Fig.1. (left) Audiovisual biofeedback system in 3T MRI. Infrared camera and marker block on the abdomen. (right) Audiovisual respiratory waveguide (blue curve) and breath hold target position (red line) with real-time abdominal position (red ball) .

Results and Discussion: Using the AV biofeedback system, the abdominal position reproducibility has been significantly improved as shown in Fig. 2. Sequential images show an insignificant difference when using AV biofeedback, while a distinct image difference is confirmed in the images from free breathing. The average signal energy calculation in the difference images has been reduced up to ~75% with the AV biofeedback system. We obtained insignificant image quality improvement overall as we had full cooperation from the human subject.

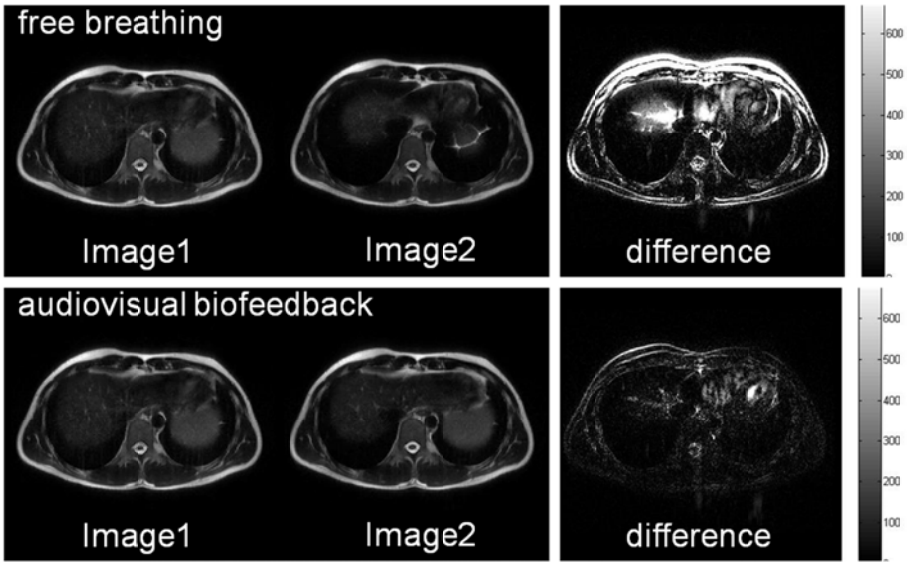

Fig. 2. (left) Two sequential breath-hold images at maximum inhalation. (right) Image difference with scale bars.

Conclusion: The study demonstrated significant improvement of abdominal position control using AV biofeedback within the MRI system. This system provides clinically applicable abdominal position control in MRI scanning which can increase image consistency and reduce motion artifacts in MRI.

1. McRobbie, D.W., et al., 2006: Cambridge University Press
2. Wang, Y., et al., Mag. Reson. Med., 1995. **34**: p. 11-16.
3. Venkat, R.B., et al., Physics in Medicine and Biology, 2008. **53**(11): p. N197.