Fat Quantification of Adrenal Adenomas Using 3D 3-Point Dixon MR Imaging: Comparison with Conventional 2D Dual Echo Chemical Shift MR Imaging

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3-point Dixon sequence can achieve high-quality fat suppression and produce four images per slice: in-phase, opposed-phase, pure water, and pure fat with reduced imaging and reconstruction time. The purpose of this study was to examine the usefulness of the 3-point Dixon technique with 3.0 T MR imaging in quantifying adrenal fat content as a marker of adrenal adenoma. Measurements of the 3-point Dixon technique were compared with conventional dual echo chemical shift gradient echo (GRE) technique and computed tomography (CT).

Materials and Methods

MR Imaging Technique: All MR imaging was performed with a 3.0-T system (Achieva; Pilips Medical Systems) using a torso. MR imaging was performed with TR 250 ms, dual TEs 1.2/ 2.3 ms, FA 60° for phantom study, and 65° for clinical study for 2D dual echo GRE (fast field echo; FFE); TR 4.3 ms, triple TEs 1.2/ 2.1/ 3.0 ms, FA13° for 3D 3-point Dixon. T1 measurements of fat and various concentrations of gadopentetate dimeglumine (Gd-DTPA) in the phantoms were performed with an inversion-recovery spin echo pulse sequence with a TR of 1,500 ms and inversion times of 10 - 1,280 msec.

Phantom Study: To explore the effect of T1 value on in- and opposed-phase MR images of fat containing tissues, we used a phantom model with a gadolinium chelate and oil. The water mixed with various Gd-DTPA concentrations (0 - 1.0 mmol/L) was layered on corn oil, which provided an oil-water interface in which to test various fractions of fat to water. The 2 cm-thick section images were obtained in the transverse plane every 1 mm step from the bottom (0% oil) to the top (100% oil) of the phantoms for various proportions of fat content. The signal intensity (SI) index was calculated as follows: SI index = (SIin - SIop)/ SIin x 100, where SIin is SI on in-phase images and SIop is SI on opposed-phase images. Quantitative measurements of SI changes between water and fat images of 3-point Dixon were defined as WF index in this study. The WF index was calculated as follows: WF index =SIfat/ (SIwater + SIfat) x 100, where SIwater is SI on water images and SIfat is SI on fat images.

Clinical Study: Fourteen consecutive patients with 15 adrenal adenomas were included in this retrospective study. The presence of adrenal adenomas was proved at biopsy, surgery, or imaging (repeated CT or MR imaging) and clinical follow-up of minimal six months. All patients were examined both MR imaging and CT (mean interval, 3.0 months). CT was performed by using a 64-detector row helical CT instrument. We compared quantitatively between CT value and SI/ WF index of various MR techniques. Furthermore we compared CT values with estimated fat fraction derived from phantom study. For each patient, SI measurements were obtained from the region of interest (ROI) in adrenal masses on in-phase and opposed-phase chemical shift images with both dual echo GRE and 3-point Dixon techniques; those of water and fat images with only 3-point Dixon techniques. We used the Pearson correlation coefficient coefficient (*R*) to assess the strength of associations.

Results

Phantom Study: The phantom exhibited T1 values of 2,150 msec for water and 228 msec for fat. The addition of Gd-DTPA of 0.25 mmol/L reduced the T1 values to 671 ms as the simulated T1 value of the adrenal grand. We used the graphs with Gd-DTPA concentration at 0.25 mmol/L for calculation of fat fraction in clinical study. The SI index reached maximum values of 78.1 (60% fat) with dual echo GRE, those of 97.6 (55% fat) with 3-point Dixon for Gd-DTPA concentrations of 0.25 mmol/L. The WF index increased with increase in fat fraction. (Fig. 1)

Clinical Study: SI index measured by dual echo GRE (R^2 0.75) and 3-point Dixon (R^2 0.76) was better than WF index (R^2 0.58) (Fig. 2.). The calculated fat fraction from SI index measured by GRE (R^2 0.77) was showed better correlation than both SI index (R^2 0.63) and WF index (R^2 0.58) measured by 3-point Dixon with similar slope (Fig. 3)

Conclusions

This study provided evidence that 3D high resolution 3-point Dixon techniques offer an alternative to 2D dual echo GRE for fat quantification of adrenal masses with higher accuracy.

Fig. 1 Relationship between fat fraction and SI/ WF index in a phantom study