Characterization of Adrenal Tumors with Single Breath-Hold In-Phase/Opposed-Phase MR Imaging at 3.0 Tesla: Comparison of Different Echo Time Pairs

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Background: Adequate characterization of adrenal tumors is necessary to plan an appropriate clinical approach. In-phase/opposed-phase magnetic resonance imaging (IP-OP MRI) has proven highly accurate in differentiating benign from malignant adrenal tumors. The diagnostic efficiency of IP-OP MRI to distinguish between adrenal adenomas and malignant lesions originates from its high sensitivity for detecting tissues with some lipid content. Adrenal adenomas generally contain variable amounts of intracytoplasmatic lipid in contrast to malignant adrenal lesions which typically do not. IP-OP MRI utilizes the interference of the fat and water signals due to the chemical shift frequency shift between the two to demonstrate a loss of signal intensity (SI) on opposed-phase (OP) images relative to in-phase (IP) images for tissues containing both fat and water.

At 1.5T, the first OP and IP echoes occur at 2.2 ms and 4.4 ms, respectively, and can be acquired within the same breath hold. However, at 3.0T the first OP and IP echoes occur at 1.1 ms and 2.2 ms, respectively, and would require unacceptably high receiver bandwidths to acquire in the same breath hold. The manufacturers' selection of TE for IP-OP MRI at 3.0T varies. Either, (A) the first OP signal (TE range: 1.5-1.6 ms) before the second IP signal (TE range: 4.4-4.9 ms) or (B) the first IP signal (TE range: 2.2-2.5 ms) is collected before the third OP signal (TE range: 5.5-6.2 ms).

Methods: We evaluated the effect of two TE pairs for single breath-hold IP-OP MRI at 3.0T for the quantitative analysis of adrenal tumors. Quantitative assessment was performed by calculating the SI index of the adrenal lesion as follows: (SI on IP – SI on OP) / (SI on IP). The reported minimal SI index threshold for adrenal adenomas, providing a 100% accuracy for differentiating adenomas from non-adenomas, ranges between 0% and 16.5% at 1.5T[1-3].

This retrospective study received a waiver of patient consent by our institutional review board. During a time period of 29 months nine patients (8 women, 1 men; mean age 68 years) with ten adrenal tumors (eight adenomas, two metastases from renal cell carcinoma (RCC); mean diameter: 2.9 cm) underwent IP-OP MRI at 3.0T. Final diagnosis was established by biopsy (n =2 tumors), interval change in size on 12-month follow-up CT (n=6), or by unenhanced CT attenuation values of less than 10 Hounsfield units (n=2). The MR imaging was performed on three different 3.0T MR scanners (Magnetom Trio (n = 6 scanned patients), Magnetom TIM Trio (n = 1), Siemens, Erlangen, Germany; Signa Excite (n = 2) GE Healthcare Inc., Milwaukee, WI) using dedicated 8-channel torso array receive-only coils. The adrenal MR imaging protocol consisted of coronal Half-Fourier acquired single-shot turbo spin echo (HASTE) or single shot fast spin echo T2-weighted images and T1-weighted gradient echo IP and OP sequence. Single breath-hold IP-OP MRI included two different acquisition schemes: (A) acquisition of the first OP echo (TE ~ 1.5 ms) and the second IP echo (TE ~ 4.9 ms) and (B), acquisition of the first IP echo (TE ~ 2.4 ms) and the third OP echo (TE ~ 5.8 ms), respectively. Acquisition with echo pair A included eight adenomas and one metastasis and acquisition with echo pair B included three adenomas and two metastases. Three adenomas and one metastasis were scanned with both echo pair A and B. The calculated SI index values separated by adenomas and metastases were graphically depicted as scatter plots for the two TE schemes.

Results and Discussion: Applying the TE scheme A, the mean SI index value for the eight adenomas measured 17.2% ± 11.0% (SD) (range, 7.4% - 35.0%) and the SI index value for the metastasis was -13.1% (Fig. 1). For the TE scheme B, the mean SI index value for the three adenomas and two metastases were 26.5% ± 14.2% (range, 15.5% - 42.5%) and 20.3% ± 4.3% (17.2%, and 23.3%), respectively. The mean SI index value for the three adenomas scanned with both schemes A and B measured 9.0% ± 2.0% (range, 7.4%-11.3%) for scheme A and 26.5% ± 14.2% (range, 15.5%-42.5%) for scheme B. The SI index value of the biopsy-proved adrenal metastasis from RCC, scanned with both TE acquisition schemes measured -13.1% for scheme A and 17.2% for scheme B. No overlap in the SI index values was seen in the scatter plot between the eight adenomas and the metastasis using scheme A, whereas, scheme B yielded a considerable overlap of the SI index values between adenomas and metastases (Fig. 1). A selected SI index cut-off value for scheme A ranging between -13.1% and 7.4% would result in a 100% accuracy for distinguishing adenomas from nonadenomas.

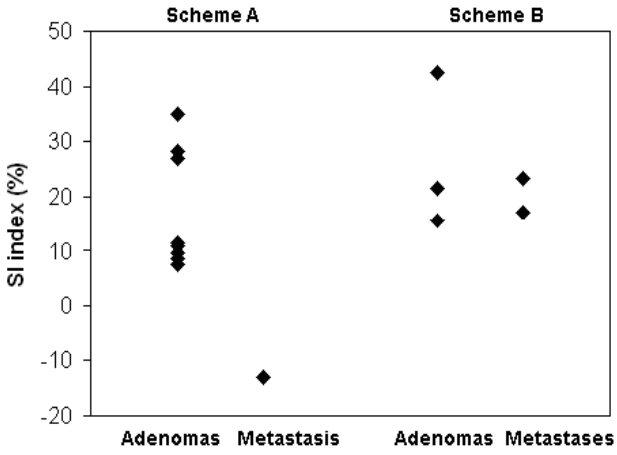

Fig. 1. - Scatter plot demonstrates the SI index values for the adenomas and metastases scanned with the TE acquisition scheme A and B. No overlap between the values of the adenomas and the metastases is seen for scheme A, however, a substantial overlap is seen for scheme B.

Using shorter TE for the IP echo than for the OP echo presented a misleading signal loss on the OP images for the two metastases. On IP-OP MRI using Scheme B two effects mainly influence the signal loss on the OP images: the chemical shift effect and the T2* decay. The latter demonstrates the most plausible explanation for the false signal loss of malignant adrenal lesions with little or no lipid content on OP images when the IP echo is acquired before the OP echo. This scenario would yield a positive SI index value, whereas the TE selection in the reverse order (Scheme A) would yield most likely a negative SI index value. Radiologists selecting shorter TE for the IP echo than for the OP echo are confronted with a diagnostic dilemma when detecting a signal loss in an adrenal lesion on the OP images, since they are not able to decide whether the signal loss is due to chemical shift effect in a fat containing adenoma or due to the T2* decay in a malignant lesion with little or no fat. Therefore, the selection of the TE scheme for chemical shift MR imaging at 3.0T may have a major impact on the diagnosis of an adrenal tumor. To avoid misclassification of adrenal tumors on IP-OP MRI, the TE of the IP echo should always be longer than the TE of the OP echo (e.g. Scheme A).

References

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