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Diffusion-weighted imaging with fat suppression using short-tau inversion recovery: Clinical utility for diagnosis of breast lesions

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AIM: To compare the utility of conventional diffusion-weighted imaging (DWI) with fat suppression using short-tau inversion recovery (STIR-DWI) for the detection of breast lesions.

MATERIALS AND METHODS: Magnetic resonance imaging (MRI) images of 56 patients (both DWI and STIR-DWI performed) were retrospectively analysed. Parameters compared between DWI and STIR-DWI were image artefacts, image signal-to-noise ratio (SNR), apparent diffusion coefficient (ADC), and contrast-to-noise ratio (CNR). Diagnostic utility was assessed using receiver operating characteristic (ROC) analysis.

RESULTS: No abnormality was detected in 17 patients, with lesions observed in 39 patients (16 benign, 23 malignant; confirmed by biopsy or surgical histopathology). The rate of image artefacts was significantly lower for STIR-DWI ($p < 0.01$): quality levels 1 (best), 2, and 3 accounted for 50%, 35.7%, and 14.3% of DWI images, and 96.4%, 3.6% and 0% of STIR-DWI images, respectively. The SNR was not significantly different. ADC values of breast lesions and normal glands were significantly lower for DWI than for STIR-DWI ($p = 0.03$ and 0.034). ADC values of malignant lesions, but not benign lesions, were significantly lower for DWI than for STIR-DWI ($p = 0.02$). CNR values of both benign and malignant lesions were not significantly different between DWI and STIR-DWI. The area under the ROC curve, for the use of ADC values to differentiate benign from malignant lesions, was not significantly different between DWI (0.931) and STIR-DWI (0.914). Taking a threshold ADC value of 1.23×10^{-3} mm^2/s, the sensitivity and specificity were 87.5% and 87% for DWI, and 87.5% and 82.6% for STIR-DWI, respectively.

CONCLUSION: STIR-DWI is adequate for clinical use in breast MRI investigations.

Introduction

Globally, breast cancer is the most common cancer diagnosed in women, accounting for 23% of all the cancer cases and 14% of the cancer deaths.[1] For many years, clinical breast examination and mammography have been the main methods employed for the diagnosis of breast cancer. However, these approaches do not always identify tumours

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located in dense breast tissue.[2–4] Thus, there has been much interest in the development of alternative techniques with improved diagnostic accuracy.

Over the years, advances in magnetic resonance imaging (MRI) have permitted its use in a wider range of diagnostic roles. Although diffusion-weighted imaging (DWI) using spin echo-echo planar imaging (SE-EPI) has proven clinically useful in the diagnosis of early-stage cerebral infarction, its utility in examining other systems of the body has been limited by the long imaging time and high sensitivity to physiological motion. However, the development of ultra-fast imaging techniques, such as single-shot echo planar imaging (SS-EPI) and multi-shot echo planar imaging (MS-EPI), has extended the use of MRI to other parts of the body.

The utility of DWI for the detection of breast cancer has been investigated,[5,6] and despite promising results, it is clear that EPI-DWI has certain limitations. Deviation of both breasts from the central magnetic field can cause magnetic field inhomogeneity, resulting in a magnetic susceptibility artefact (particularly for higher b-values), while the higher composition of fat in the breast can cause chemical shift artefacts. In addition, breathing of the patient may cause motion artefacts. These artefacts can cause loss of image detail and impair the detection of lesions, but their influence has been reduced by improvements in MRI hardware and software. For example, parallel acquisition technology, using a phased array of multiple surface coils, has shortened the acquisition time and decreased the magnetic susceptibility artefact for a single stimulating EPI sequence, albeit with the disadvantage of a reduced signal-to-noise ratio (SNR) of the image.

In 2004, Takahara and colleagues described whole-body DWI with background body signal suppression (DWIBS).[7] Their method was based on conventional single stimulating SE-EPI-DWI, and used sensitive encoding (SENSE) combined with short-tau inversion recovery (STIR) technologies to perform thin-section scanning and acquire high-resolution DWI images. The major advantages of this approach are that scanning is performed under free breathing, and that repeated stimulations and acquisitions are available, improving the image SNR and both spatial and temporal resolution, while shortening the acquisition time. Full suppression of the background signal and improved image quality allows DWIBS to detect lesions with more sensitivity, and this technique has now been applied successfully to the imaging of various organs, such as the head and neck, chest, parenchymal organs in the abdomen, prostate, limbs, and spinal column.[8–14]

Currently, the clinical use of DWI with fat suppression using STIR (STIR-DWI) for imaging of the breast is still in its infancy, and there is a paucity of studies directly comparing its utility against that of conventional DWI for the diagnosis of breast cancer. The present study was designed to investigate the image features of STIR-DWI and DWI, and their clinical utilities in the diagnosis of breast lesions, by comparing the image artefact rate, image SNR, contrast-to-noise ratio (CNR), and apparent diffusion coefficient (ADC) values of the lesions between these two techniques.

Materials and methods

Patients

This was a retrospective study of the medical records of 59 consecutive patients who underwent MRI with diffusion, between September 2011 and March 2012, at the First Affiliated Hospital of Chongqing Medical University, China. The study was approved by the Institutional Review Board of the First Affiliated Hospital of Chongqing Medical University, and informed consent was not deemed necessary due to the retrospective design. The included patients were those that had received MRI investigations of the breast, with the examined sequences including DWI and STIR-DWI; both normal and abnormal MRI findings were included.[15] Patients with previous breast biopsy or neoadjuvant chemotherapy before the MRI investigation or severe artefacts on DWI imaging were excluded from the study.

MRI investigations

Images were obtained using a Signa HDxt 3 T MRI system (GE Healthcare, Milwaukee, WI, USA) with a dedicated, bilateral, four-channel breast coil (CH Breast Array by MRI Devices, GE Healthcare). The patient was imaged in a prone position, and the imaging sequences and parameters were as follows. For DWI, the axial SS-EPI sequence and array spatial sensitivity encoding (ASSET) technique was used [6000 ms repetition time (TR); 66.3 ms echo time (TE); 320 × 256 matrix; 4 mm section thickness; 1 mm interval; 32 × 32 cm field of view (FOV); number of excitation (NEX) = 6]. Sensitizing diffusion gradients were applied sequentially in all three orthogonal directions, with horizontal phase-encoding direction and b-values of 0 and 800 s/mm^2, respectively. Single acquisition was performed and the total acquisition time was 2.30 min. The number of sections was 30.

For STIR-DWI, the axial SS-EPI and ASSET technique was used [6000 ms TR; 66.3 ms TE; 320 × 256 matrix; 4 mm section thickness; 1 mm interval; 32 × 32 cm FOV; NEX = 6; 220 ms inversion time (TI)]. Sensitizing diffusion gradients were applied sequentially in all three orthogonal directions, with horizontal phase-encoding direction and b-values of 0 and 800 s/mm^2, respectively. Two acquisitions were performed and the total acquisition time was 3.20 min. The number of sections was 38.

For T2WI, sagittal T2 fast spin-echo, with ideal water–fat separation imaging was performed [3600 ms TR; 97.6 ms TE; echo train length (ETL) = 17; 41.7 kHz bandwidth; 320 × 192 matrix; 4 mm section thickness; 0.5 mm interval; 24 × 24 cm FOV; NEX = 6], with an acquisition time of 4.41 min.

For dynamic contrast-enhanced MRI (DCE-MRI), T1-weighted fat-suppressed three-dimensional (3D) fast spoiled gradient-recalled echo sequences were performed before and after the intravenous administration of 20 ml gadopentetate dimeglumine (Magnevist; Berlex Laboratories, Wayne, NJ, USA) at a flow rate of 2 ml/s, followed by a 20 ml saline flush administered at the same rate. The first