

Chapter (3)

Material and Methods

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MATERIAL AND METHODS

Material

This cross-sectional study conducted between March 2010 and January 2012 at Saudi German Hospital. Breast MRI was performed for one hundred (100) Female patients with breast lump (age range, 20–81 years). This study was granted ethical approval from Saudi German Hospital.

MRI was performed using a 1.5-T system (Magnetom symphony 1.5 Tesla, Siemens–Germany). A body coil was used for transmission, and a double breast coil (four-channel breast array coil) was used for MRI.

Methods

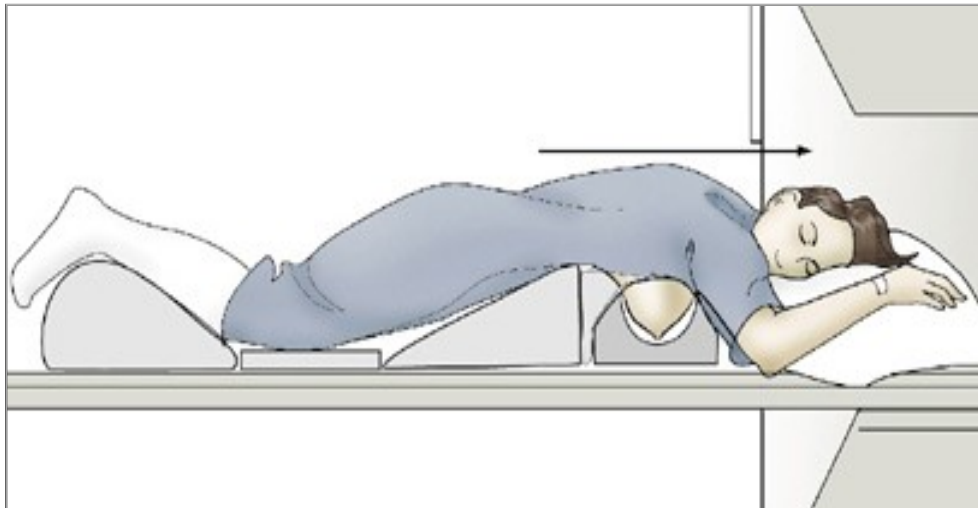
The data was collected from patients with the following inclusion criteria:

- 1- Clinical palpable breast lump or nipple discharge.
- 2- Equivocal breast mass on the basis of mammo-sonographic finding
- 3- Diffuse breast enlargement without significant mass lesion on mammo-sonography
- 4- Post-operative follow-up

Exclusion Criteria

- 1- Patients with simple breast cyst confirmed by ultrasound
- 2- Patient with mastitis confirmed by ultrasonography
- 3- Recent post-operative patients (less than 3 month)

Breast Mass Protocol



Patient preparation

- Start intravenous line (20 or 22 gauge IV).
- Valium (5-10mg po) or Xanax (1-2 mg po) if patient is claustrophobic.
- Ear plugs

Coil: Dedicated breast coil is optimal for superior signal to noise.

Patient Positioning: Prone, head first. Patient must have comfortable pillow for head and arms. Be careful that patient is centered in the coil. There is a tendency for patient to slide too far superiorly in the coil. To counteract this tendency, ask the patient to slide 2-3 cm toward feet after she lies prone on the coil.

Landmark: Mark at center of the breast coil

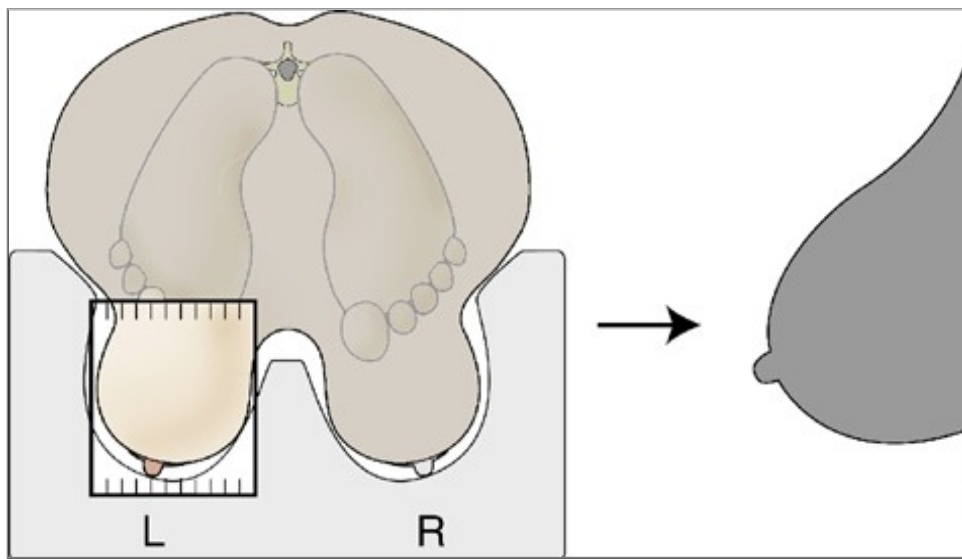
Protocol

Series 1: 3-Plane Localizer

This is a quick localizer sequence obtained in three planes. It is used to confirm optimal patient positioning within the breast coil. The sagittal views are most helpful. Bright signal from the inferior aspect of the coil should end at the inframammary fold. This will allow maximum coil signal superiorly.

Series 2: Sagittal T1

- Prescribe graphically on an axial slice that is centered between the axilla and inframammary fold, not the center of the breast. This will allow better visualization of the axillary nodes.
- Scan direction should be from left edge to right edge of the breast.
- One or both breasts may be scanned depending on the clinical circumstances.
- Make field of view large enough to include axilla to assess lymph nodes.



Series 3: Axial Inversion recovery (IR)

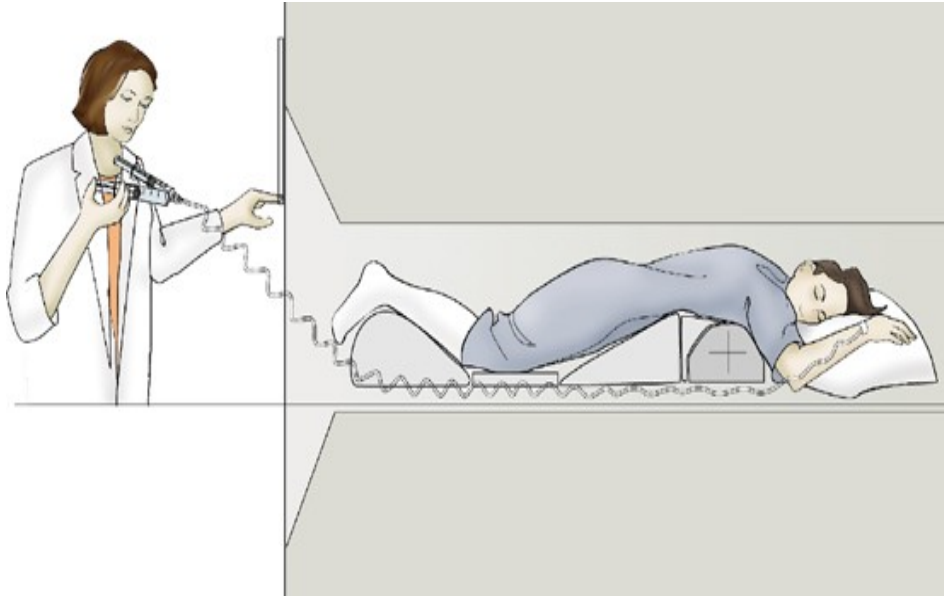
This sequence is helpful for differentiating the cysts from tumor or fibrosis.

Series 4&5: 3D Gd high temporal resolution

- This is the main sequence to identify and characterize malignant lesions.
- The scan plane may be sagittal for a single breast or axial for both breasts. With ‘Vibrant’ it is possible to prescribe 2 separate volumes, one for each breast
- Keep FOV as small as possible but include both breasts. This helps to ensure homogeneous fat saturation and optimal spatial resolution.
- Longer scan time generally gives higher spatial resolution as a trade off to high temporal resolution. In the Scanning Range area the following options are available: FOV, slice thickness and number of scan locations. An optimal FOV is generally around 28-32 cm depending on patient size. If a larger volume is necessary, it is preferable to increase the slice thickness over the number of scan locations. This will allow one to cover a larger volume in the same amount of time, obviously at the expense of temporal resolution. However the “ZIP2” option allows obtaining relatively thin reconstructed images. These parameters are designed for imaging the breast tissue pre and post contrast. If one is interested in including the axillary region, a larger volume maybe necessary. This can be done by increasing the number of scan locations at the expense of temporal resolution. If the scan time is increased, check the multiphase screen as you may need to decrease the number of phases from nine to eight.
- All pre, during and post-Gd acquisitions should be done in the same series to facilitate optimal subtraction technique. It is important to turn on the multiphase

option to ensure that the scanner memory can accommodate the number of post contrast sequence planned.

- It is very important that the patient does not move between the pre, during and post-Gd scans.



- To minimize the chance of motion, be sure to start the IV line before performing the pre-contrast acquisition. In general, the IV should be placed before the patient enters the magnet because the prone position can make starting the IV extremely difficult.
- This sequence is obtained with the “ZIP2” option turned on. This allows you to obtain the images with a 5-6 mm slice thickness but to reconstruct the images at 2.5-3 mm for interpretative review.
- Emphasize with the patient the importance of avoiding coughing, wiggling or other large motions during or in between these scans.
- Manually prescan to ensure the best possible fat saturation (use cstun). If homogeneous fat suppression is a problem with the larger FOV used for axial imaging, the scan can be performed without fat suppression and supplemented with a post processing subtraction technique for optimal visualization of areas

of contrast enhancement. With ‘Vibrant’ it is possible to optimize field homogeneity for two regions, one for each breast.

- As the machine readily defaults to frequency R/L direction, make sure that the frequency direction is A/P. If the primary area of interest is in the axillary tail region, you may consider A/P phase encoding direction with R/L frequency encoding direction. This is the one exception to frequency A/P because if phase is A/P then cardiac and respiratory motion creates phase artifact that superimposes on the breasts.

Imaging techniques

Before the administration of contrast material, Sagittal T1 flash 3D 2 slab sequence (TR/TE: 26 /6.41 ; flip angle,30°; field of view, 200 mm; matrix, 256 x 90; slice thickness, 0.8 mm; slab number 160 mm; time of acquisition, 5.34 minutes; and axial T1-weighted images (TR/TE: 500 /13 ; flip angle,150° ; field of view, 311 mm; matrix, 256 x 256; slice thickness, 3.5 mm; time of acquisition, 163 seconds) were obtained. Diffusion-weighted images were obtained with a spin-echo single-shot echo-planar imaging sequence incorporating the generalized autocalibrating partially parallel acquisition (GRAPPA) algorithm for parallel acquisition. The parameters were as follows: TR/TE: 3,600/94; field of view, 340 mm; matrix, 120 x 100; receiver bandwidth, 1,346 Hz per pixel; slice thickness, 3 mm; time of acquisition, 1.21 minutes. Motion-probing gradient pulses were applied along the x, y, and z directions with b values of 500, 1,000, 1,500, 2,000, and 3,000 s/mm². Spectrally adiabatic inversion recovery was used for fat suppression.

Dynamic MRI using a 3D fat-suppressed (flash 3D) sequence with parallel acquisition was performed before and after injection of a bolus of gadolinium DTPA (40 mm/kg) at a rate of 2 mL/s, followed by a 20 mL saline flush administered using an automatic injector. Both breasts were examined in the axial plane; 1 minute before contrast then break for 20 second followed by six measurements, the first (1.21-2.21) minutes, second (2.21-3.22) minutes, third (3.22-4.23) minutes, fourth (4.23-5.23) minutes and fifth (5.23-6.24) minutes after contrast injection, respectively. The parameters for

dynamic MRI were as follows: TR/TE: 8.4/4.76; flip angle, 20°; field of view, 300 mm; matrix, 484 x 75; receiver bandwidth, 380 Hz per pixel; interpolated slice thickness, 1.5 mm; partitions, 1; and time of acquisition, 6.24 minutes. Sagittal T1 flash 3D 2 slab sequence without parallel acquisition was obtained at 5.34 minutes after contrast injection; (26/6.41; flip angle, 30°; field of view, 200 cm; matrix, 256 x 90; receiver bandwidth, 260 Hz per pixel; interpolated slice thickness, 0.8 mm; partitions, 1; time of acquisition, 5.34 minutes.

Image Interpretation

One radiologist with long years of experience in breast MRI evaluated contrast-enhanced MR images. Initial enhancement patterns were evaluated using the first- and second-phase dynamic images, and delayed enhancement patterns were assessed using the third-phase dynamic images.

MRS

After all of the MRI sequences had been performed, single-voxel MRS (SVS) was performed using a point-resolved spectroscopy sequence (PRESS). The parameters of MRS were 1,500/135; voxel size, 12 x 12 x 12 mm³; 192 acquisitions; acquisition duration 1024; spectral; -1.5 data points; and time of acquisition, 4-5 minutes. For voxel placement, axial, coronal and sagittal contrast-enhanced T1-weighted MR images were used as scout images, and a voxel of interest was placed to include the lesion. Shimming was performed automatically first, followed by manual shimming on the water resonance for optimization of the homogeneity in each volume of interest. Water-peak line widths of 8–13 Hz (full width at half-maximum (FWHM)) were typically achieved. After the shimming procedure, spectra were acquired with water suppression by applying three chemical shift-selective excitation pulses. By spectral suppression using dual band-selective inversion with gradient dephasing, the transverse magnetization was selectively dephased before and after the second spin-echo pulse.

Data Processing and Spectral Interpretation

The spectroscopic data-processing protocol was saved and linked with the measurement protocol in the software (Magnetom symphony, Siemens-Germany) to ensure that data processing was identical for each measurement. A Hanning filter with a window width of 400 milliseconds was applied. The peaks of choline and water fitted with a gaussian function from 3.18 to 3.32 ppm for choline and at 4.7 ppm for water. Using the residual water signal as a reference (4.7 ppm), a choline peak at 3.27–3.28 ppm assigned to glycerophosphocholine, taurine, and myo-inositol was defined as benign, whereas a peak resonance at 3.22–3.23 ppm assigned to phosphocholine was defined as malignant

Diffusion-Weighted Imaging

One radiologist with long years of experience in breast MRI visually analyzed high-b-value ($b = 1,500 \text{ s/mm}^2$) images. A lesion was defined as positive for malignancy if a focal area of high signal was detected corresponding to an enhancing lesion on contrast-enhanced MRI. The lesion was identified by comparing the contrast-enhanced MR images and diffusion-weighted images. Each set of images was obtained in three directions: axial images and sagittal and coronal multiplanar reformation images. the ADC values of mass or focal lesions were calculated for the positive cases. The highest-signal portion of the lesion was visually identified on high-b-value images, and a circular region of interest (ROI) was placed manually on that portion of the lesion. ADC values were automatically displayed through software in the machine.