STIR versus SPAIR in Breast Imaging: a Case-Based Discussion

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Purpose

The purpose of this article is to illustrate the varying appearances of breast cysts for different inversion recovery imaging sequences such as STIR and SPAIR.
It illustrates a specific pitfall in interpretation of inversion recovery techniques (for lipid void) in breast MR imaging. It includes schematic and pictorial illustrations to describe this pitfall, with imaging from a clinical case.

Introduction

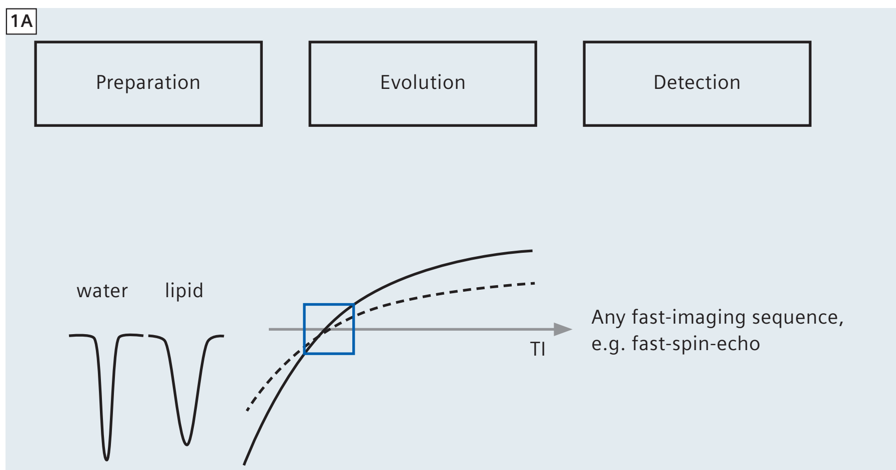
Standard breast MR protocols, e.g. for screening of high-risk patients, encompass methods for water-lipid separation [1]. To optimally assess the water component in fibroglandular tissue, fat suppression scans based on T1 relaxation values are commonly used, namely STIR (short TI inversion recovery) (Fig. 1A) or SPAIR (spectral selection attenuated inversion recovery) (Fig. 1B). Both sequences embody an inversion recovery scheme and acquire the image data after a time delay (called inversion time TI), when the longitudinal magnetization of the signal from lipids is zero.

What is the difference between STIR and SPAIR?

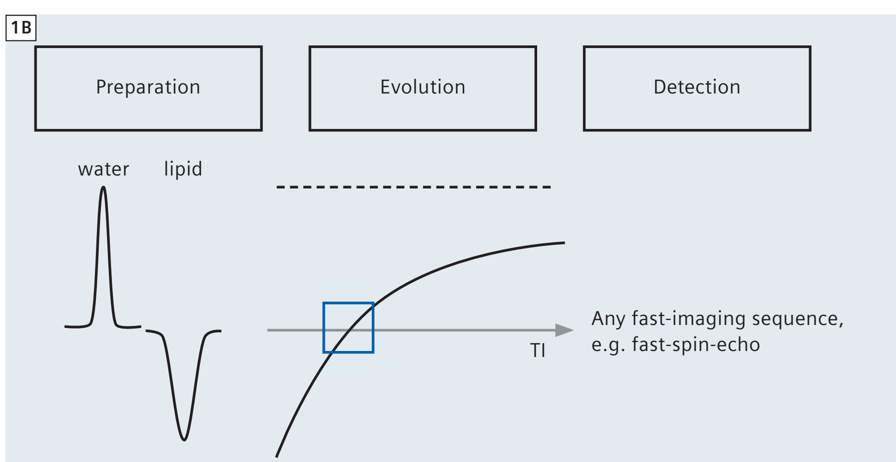
The inversion-recovery (IR) technique STIR is chemically non-selective, but spatially selective, i.e. the inversion pulse affects all tissues, but only for the respective slice. SPAIR in contrast is chemically selective, but spatially non-selective, i.e. only the fatty tissue is inverted, but this applies to the whole volume of all slices. Consequently, the frequency of inversion pulses for each slice is much higher for SPAIR (TR / number of slices). The steady-state magnetization of fatty tissue is consequently lower, resulting in a shorter TI for zero crossing of the fat magnetization.

What are the strengths and weaknesses of STIR and SPAIR?

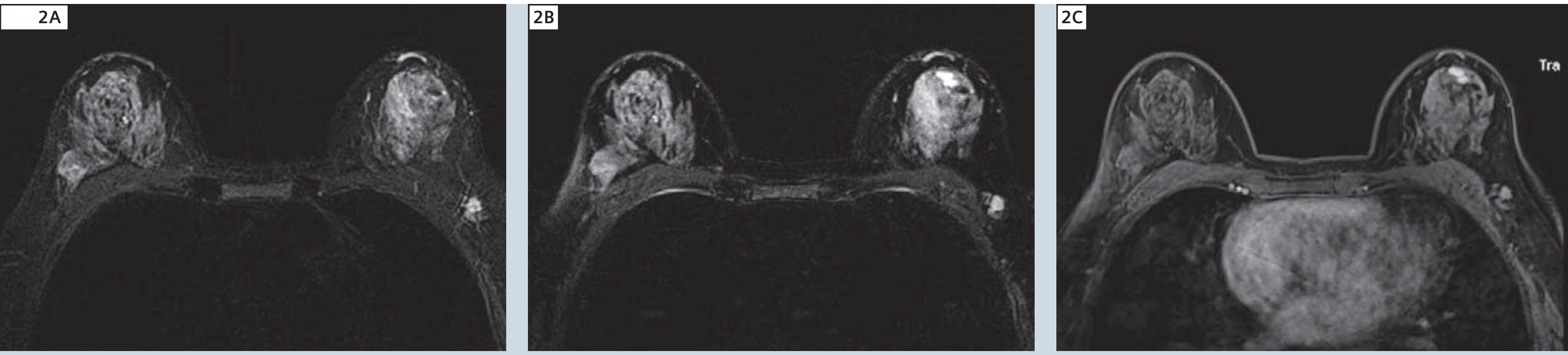
A significant but detrimental feature of STIR is that the water signal follows the



1A Diagram of STIR consisting of three time periods, namely the preparation period (non-selective inversion), the evolution period (T1 recovery), and the detection period. Note that any other tissue (dashed line) with a T1 similar to that of lipids (solid line) is nulling likewise.



1B Diagram of SPAIR. The spectral selective inversion pre-pulse is set on the lipid frequency, leaving any other tissue unaffected (dashed line) during both the preparation and the evolution period.



2 Breast MR images of a 49-year-old woman with cysts containing proteinaceous fluid. **2A:** STIR with TR/TE/TI 4200/93/230, **2B:** SPAIR with TR/TE 4000/86, **2C:** T1-weighted gradient echo image TR/TE 4.9/1.9.

same scheme of inversion recovery although it has a different T1 value. This leads to an intrinsically low signal-to-noise ratio as opposed to SPAIR which leaves the water signal undisturbed. We illustrate this with the following case of breast cysts with short T1.

Pictorial illustration

A 49-year-old patient was selected for high-risk screening in MRI. No prior mammogram or ultrasound of the breasts was performed for the patient. Physical examination found no palpable mass in either breast.
MRI was performed on a 3T scanner (MAGNETOM Verio, Siemens Erlangen, Germany). The system was equipped with an open 8-channel breast array coil. The examination protocol consisted of three steps. The first involved STIR / SPAIR. In the second step, dynamic contrast-media enhanced 3D T1-weighted gradient echo images were collected. MRI of the breasts demonstrated two circumscribed oval masses at the 12 o'clock position in the left breast. These two oval masses were isointense to hypointense on the STIR images (Fig. 2A), but hyperintense on SPAIR images (Fig. 2B). Figure 2C shows a pre-contrast T1-weighted image for reference.
In the axial subtracted images, these oval masses demonstrated rim enhancement. They probably represent inflamed cysts containing proteinaceous fluid or cysts complicated by hemorrhage.

Discussion

Simple breast cysts are round or oval with sharp margins. Simple cysts have very high T2 signal and display no internal enhancement with contrast. Breast cysts with proteinaceous content may demonstrate high signal on T1-weighted images with corresponding lower signal on T2-weighted images. In inflamed cysts, enhancement may occur in the tissue around the cyst. This may appear as a mass with rim enhancement on subtracted images.
When water is bound to a hydrophilic macromolecule such as a protein, it forms a hydration layer. This lowers the motional frequencies of water which results in shortening of T1. As a point of reference, proteinaceous fluid has a T1 that is between that of fat (with shortest T1) and bulk water (with longest T1) [2]. The MR signal characteristics are thought to correlate with protein content or hemorrhage within the cysts. There are several reports concerning the relationship between cyst protein concentration and signal intensity on T1-weighted MR images [3]. This is supported by the similarity to CT [4]. An almost linear relationship is reported between protein content and the attenuation value of cyst fluid. The attenuation can be in the range of that of soft tissue and thus mimic a tissue mass.

How do T1 changes affect the STIR image contrast?

Any other tissue with a T1 similar to that of lipids then also appears strongly attenuated (Fig 1A). This inconsistency may confuse the unwary when looking at the same tissue in a different way, e.g. on T1-weighted MRI.
On the other hand, STIR is insensitive to B_0 inhomogeneity, and thus potentially permits larger fields-of-view when compared to conventional fat suppressed images and also has the ability to scan off-center; SPAIR may not work well in regions with reduced homogeneity, e.g. due to proximity to clips or generally susceptibility changes [5]. But as shown in this exemplary case, SPAIR should be used in cases where water-based tissue lesions may have a T1 similar to that of lipids, because the non-selective scheme of STIR can provide misleading results.

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