

Single-shot SSFP for Imaging of Edematous Myocardium in Patients

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Introduction: Cardiovascular MRI can be used to detect myocardial edema, which is a characteristic of patients with acute myocardial infarcts. Current techniques (such as the triple-inversion recovery prepared T₂-weighted turbo spin echo sequence (STIR)) occasionally fail in difficult cases, such as patients with poor ejection fraction or cardiac arrhythmia.

SSFP (steady-state free precession) sequences are T₂/T₁-weighted in the steady-state, and therefore should see elevated signal intensity in edematous segments of myocardium because of the long T₂/T₁ ratio of water relative to other myocardial components. SSFP also has a high imaging efficiency. This should allow for imaging in a single cardiac cycle in difficult cases.

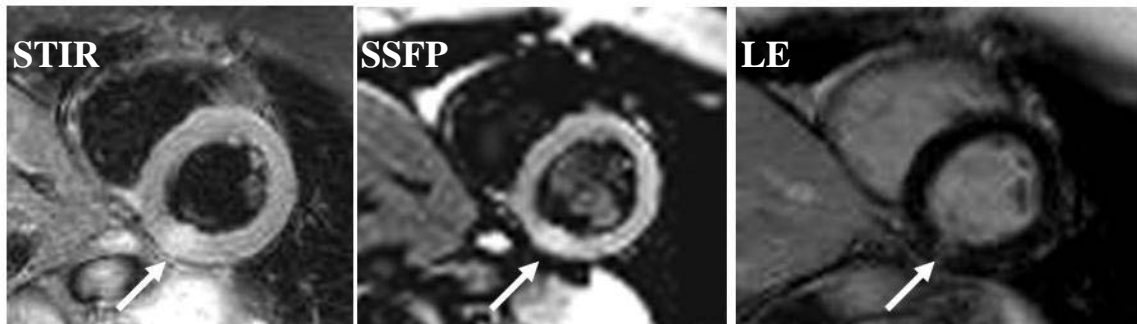
Purpose: To demonstrate the feasibility of using single-shot SSFP to image edema in acute infarcts in patients.

Methods: A standard SSFP sequence with a large (31) number of dummy pulses combined with a linear encoding scheme was used to achieve strong T₂/T₁ image contrast during the acquisition of the central lines of k-space. All imaging data was acquired in a single heart beat. In a second heartbeat, coil profile information was acquired which was used during postprocessing to remove signal inhomogeneities caused by the coil sensitivity, as described previously (1). A standard double inversion dark blood preparation was applied immediately after the R-wave to null the blood signal in the left ventricle. Imaging parameters were as follows: TR/TE/flip angle = 3.0 ms/1.5 ms/90°; matrix = 78 x 128; Field-of-view = 267 x 380 mm²; GRAPPA parallel imaging scheme; iPAT factor = 2.

This study was carried out in 6 patients (mean age = 55 years) referred to our centre for myocardial tissue characterization due to ischemic heart disease and was approved by the local institutional review board. These patients were scanned using the above T₂-sensitive single-shot SSFP technique. They were also scanned in the same slice position using a conventional T₂-sensitive triple-inversion prepared TSE sequence (STIR) for comparison.

Data was analyzed using a validated software package with a modified 17-segment model. In each slice, a region of interest was drawn in myocardial territory which should be unaffected by ischemia (as determined by their clinical referral). All pixels which had a signal intensity two standard deviations greater than the signal intensity of this remote area were considered positive for edema. If a group of 7 or more contiguous pixels were present in a myocardial segment in the STIR image, that segment was considered to be positive edema. Similarly, if 3 contiguous pixels were present in a segment in the SSFP image, that segment was considered positive for edema (different numbers of pixels for SSFP vs. STIR were used to compensate for the different pixel sizes of the two techniques).

Results: Single-shot SSFP was successful in all patients. All data sets were acquired in <2 seconds. Typical results are shown in the Figure. A total of 84 segments were evaluated. Of the 32 positive for edema using the STIR sequence, 24 were also positive on the SSFP sequence. Of the 52 negative for edema on the STIR sequence, 45 were also negative on the SSFP sequence.



T₂-weighted STIR (left) and single-shot SSFP (middle) with a hyperintense area in the inferior wall. In this patient, a late enhancement (LE) protocol was also applied (right), which shows a similar hyperintense region in the same segment.

Conclusion: Single-shot SSFP can be used to detect areas of edema signal in patients. Some discrepancies still exist between the STIR and SSFP sequences, but some of these may be due to the improved coil sensitivity correction strategy used by the SSFP sequence compared to the STIR sequence. Additionally, all patients enrolled in this study had a regular cardiac rhythm and were able to hold their breath for >10 s. Even with decreased sensitivity, SSFP may ultimately be able to provide previously unavailable information in challenging cases. Further studies are warranted in patients with irregular rhythms and/or difficulty with longer breath holds.

Reference

1. Kellman, PK et al. MRM 57: 891-897 (2007)