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Poster presentation

Myocardial Perfusion Imaging artifacts: centric h-EPI and its sensitivity to frequency errors

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Introduction

Clinical myocardial perfusion often uses Echo-Planar-Imaging, in a multishot "hybrid" variety using centre-out phase-encode-order ("h-EPI") [S Ding, et al., MRM, 39:514, 1998] for robustness against susceptibility dephasing of signal within pixels, especially during first-pass of paramagnetic Contrast-Agent (CA). However, this sequence may be sensitive to frequency errors.

Purpose

We examined the artifacts, specifically whether they could cause subendocardial Dark Rim Artifacts (DRA) mimicking perfusion defects in patients.

Methods

Clinical h-EPI stress/rest perfusion studies were reviewed after phantom images drew our attention to the off-resonance sensitivity of the h-EPI technique. All work was done at 1.5 T (Avanto, Siemens); h-EPI (4 echoes); TR/TE 5.1/1.7 ms; pixel size 2.8 × 2.8 × 8 mm; flip angle 30 deg; bandwidth 1860 Hz/pixel; saturation-recovery (TI = 90 ms); TSENSE with R = 2; Gd-based CA 0.1 mmol/kg at 3.5 ml/s. The sequence was also used to image across a hollow diamagnetic gelatine cylinder containing 12.5 mmol/L Gd-DTPA solution, forming a magnetostatic and relaxation-time model of the LV during CA first-pass. Phantom images were acquired at two scanner reference frequencies, approximating the gelatine "myocardium" and LV "blood" frequencies. For comparison, the phantom was also imaged with a balanced-SSFP perfusion sequence. For one in-vivo perfusion study, accumulated phase-errors corresponding to scanner reference frequency offsets were applied to the stored raw-data and images were repeat-reconstructed to examine h-EPI's sensitivity to the frequency used for the patient.

Results

When the reference frequency was set to myocardium (Figure 1 left), the LV blood "split" into two superimposed copies 5 mm above and below its true location (red-arrows) along the phase-encode direction. Conversely using the blood frequency (Figure 1 centre), the LV blood was imaged sharply, whereas the off-resonance myocardium split (green-arrows); explained by the opposite phase-encode directions of data collection of centre-out h-EPI. Part of the myocardial splitting deepened the Gibbs DRA (yellow-arrows). BSSFP is also shown (Figure 1 right).

Clinical examples of this effect occurred (extreme example Figure 2; less prominent Figure 3 left), probably dependent on scanner reference frequency and shimming. Because this could not be proved during clinical scanning, the effective scanner reference frequency was changed by raw-data reprocessing (Figure 3 right): increased lateral wall sharpness, but degraded the septum, implying a frequency slope across the heart in this patient.

Conclusion

In clinical use, the h-EPI centre-out phase-encode order is sufficiently sensitive to frequency offsets that phase-encode "splitting" of the endocardial border may degrade image clarity and even generate subendocardial DRAs along the phase encode direction.

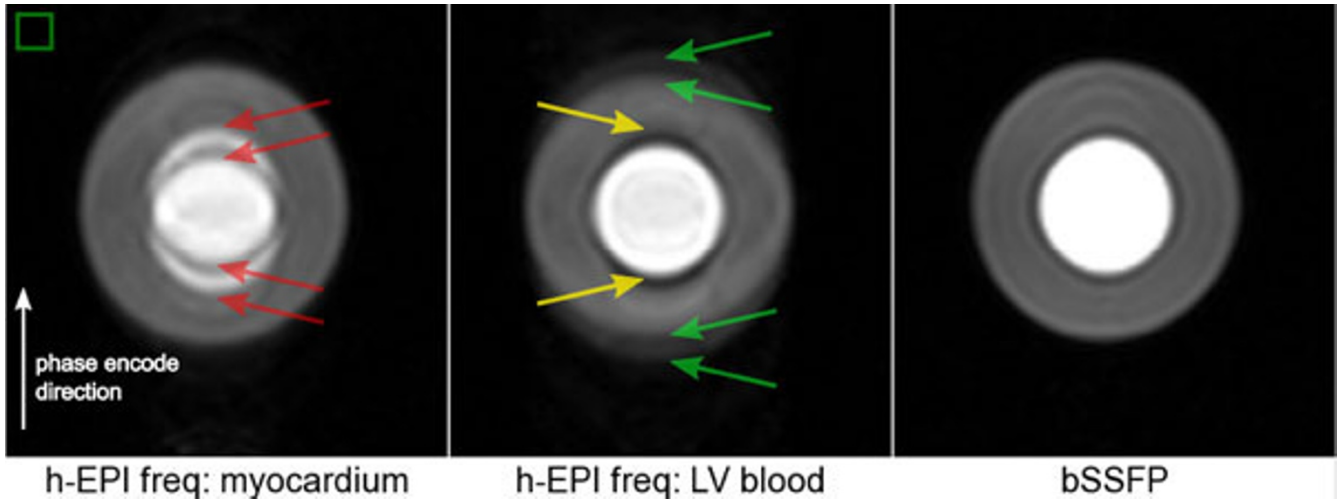

Figure 1
Phantom images with h-EPI (for two differenct scanner reference frequencies: Myocardium (left), LV blood pool (centre)) and with the bSSFP sequence (right). This phantom contained no boundary material between the gelatine and the solution therefore Gibbs artifacts were seen in the subendocardial border. Gibbs was the only visible artifact in the bSSFP image, while th h)EPI contained additional frequency-error artifacts pointed by the arrow. A green square with 1 cm side length is shown (top left) to scale the images.

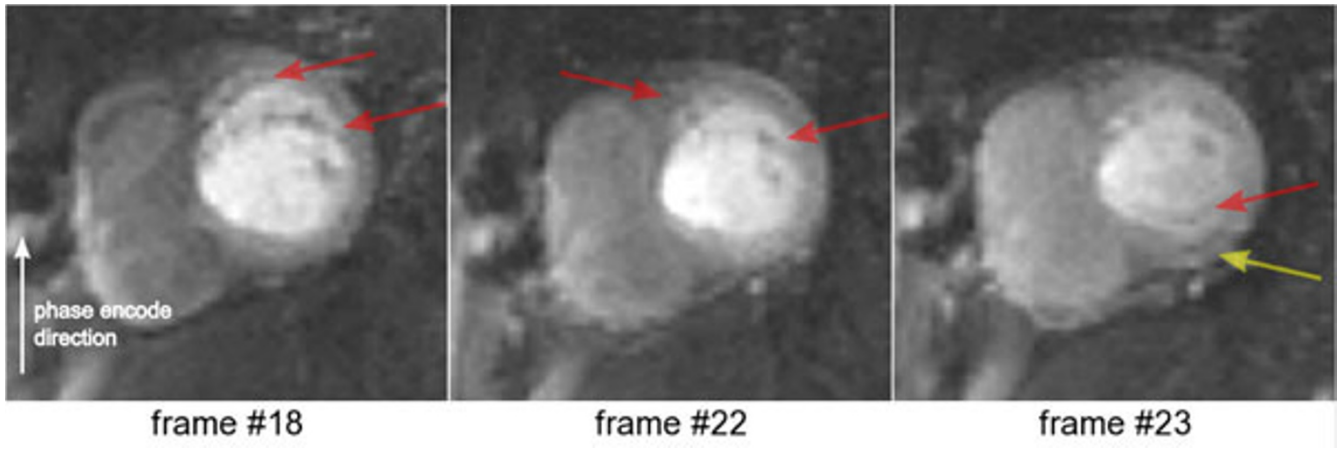

Figure 2
Three frames of a basl slice during the first pass of CA with evident splitting of the myocaridal wall (red arrows). A DRA was visible in the inferior myocardial segment of frame # 23 (yellow window).

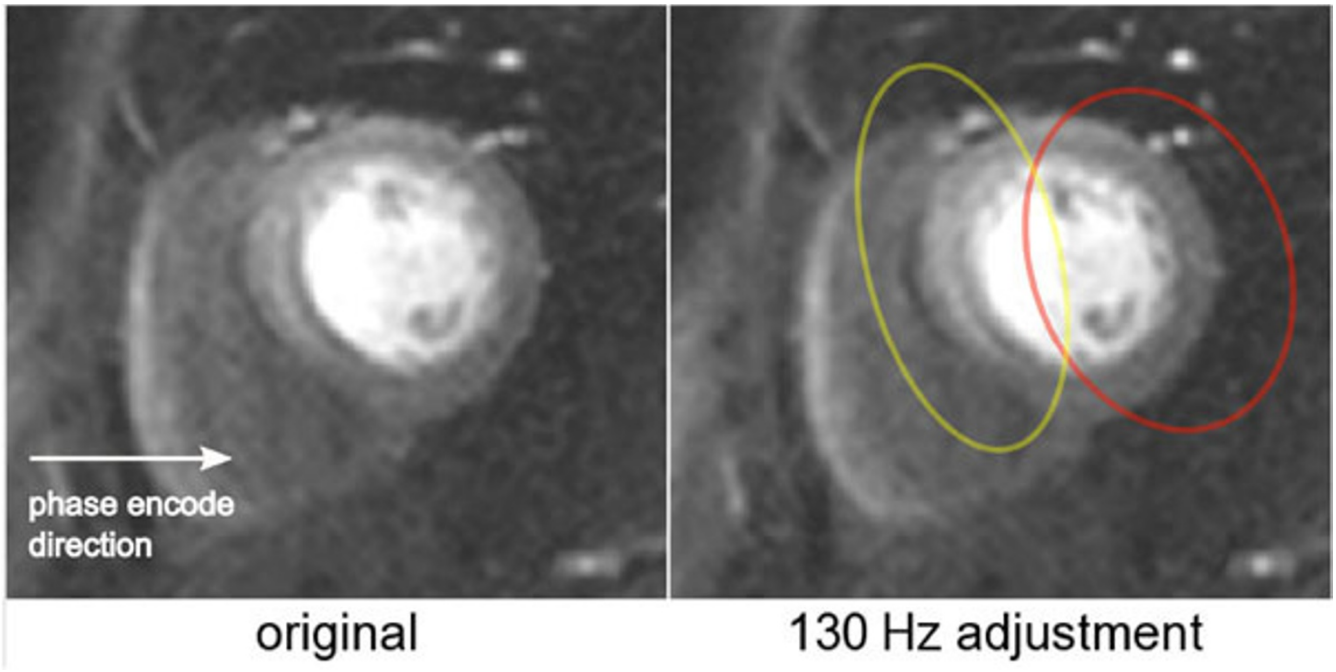

Figure 3
Left: original perfusion image. Right: original image after raw-data reprocessing (reference frequency shift of 130 Hz): sharpened the region in proximity of the lateral wall (red circle), degraded septal region (yellow circle).