Pericardial Effusion or Epicardial Fat? Improved Discrimination with Phase-Sensitive Inversion Recovery MRI

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INTRODUCTION

Pericardial effusion is a common finding during routine cardiac imaging. In a large population-based study, prevalence exceeded 15% in the oldest cohort [1]. Additionally, an incidental discovery of pericardial effusion may provide significant clues to underlying disease and therefore, be an important tool in delineating prognosis [2,3].

A typical cardiac MRI examination includes an evaluation of myocardial function using steady-state free precession (SSFP) cine and myocardial viability with gadolinium-enhanced magnitude-reconstructed inversion recovery (Mag-IR). Despite markedly different T_1 tissue properties, SSFP and Mag-IR demonstrate poor contrast between pericardial effusion and epicardial fat, potentially obscuring the accurate identification of pericardial effusion.

Phase-sensitive inversion recovery (PS-IR) is a recently validated technique for detecting myocardial infarction [4]. Unlike Mag-IR, PS-IR eliminates background phase and preserves the sign of the desired magnetization during inversion recovery [5,6]. It is not as sensitive to the selected inversion time (TI), thereby decreasing the chance of a reduction in contrast due to a sub-optimal TI.

As PS-IR maintains the polarity of short and long T_1 tissues, the aim of the present study was to determine the ability of PS-IR to better differentiate pericardial effusion from epicardial fat compared with conventional SSFP and Mag-IR imaging.

METHODS

Study Population: Patients referred for a clinical cardiac MRI examination at either the National Institutes of Health or Suburban Hospital.

Imaging Protocol: Imaging was performed using a GE Signa CV/i 1.5T MRI system and a four-element cardiac phased array. In general, SSFP (short- and long-axis) was the first sequence acquired following scout images. Following a cumulative dose of 0.2 mmol Gd-DTPA per kg body weight, a stack of short-axis slices was acquired in all patients for inversion recovery.

Imaging Sequences:

Steady State Free Precession (SSFP)

8mm slices in short- and long-axis at a temporal resolution of 40-50 ms and an in-plane spatial resolution of 1.8-2.0.

Gadolinium-Enhanced Inversion Recovery (Mag-IR and PS-IR)

A fast gradient-recalled echo pulse sequence was used with interleaved phase-encode ordering. A nonselective adiabatic IR pulse was applied every other heartbeat. Images were acquired in mid-diastole using a prospectively gated segmented acquisition of k-space over twelve heartbeats during a single breath-hold. For phase sensitive reconstruction (PS-IR) a background reference image was obtained at the same cardiac phase on alternate heartbeats during the same breath-hold acquisition. Using Gd-DTPA, the inversion recovery acquisition sequence requires 2 heart beats for near full magnetization recovery. Therefore, it is possible to acquire the reference image during alternate heart beats without increasing the breath-hold duration. The reference image is used to estimate both the background phase and surface coil field maps. The PS-IR pulse sequence is outlined in Figure 1.

Typical image acquisition was performed 20 minutes following administration of 0.2 mmol Gd-DTAP per kilogram body weight using a TI of 300ms.

Data Analysis:

Region-of-interest (ROI) measurements were made to measure signal intensity of blood, myocardium, epicardial fat, pericardial effusion, and noise. Signal intensity of blood was measured in the left ventricular cavity. For myocardium, only viable segments were used. Contrast-enhanced myocardium was not measured. Epicardial fat was typically measured in the interventricular groove. Pericardial effusion was measured in the most pronounced effusive region. Noise was calculated for SSFP and Mag-IR signal intensity correction.

RESULTS

Effusion Prevalence

From this retrospective series of 392 consecutive patients, 53 patients had a pericardial effusion. The effusions were classified as small (42 patients), moderate (8 patients), and large (3 patients) using standard echocardiographic semi-quantitative measurements [3]. Of the 42 patients diagnosed with a small effusion, 28 of the effusions were less than 5mm in size.

Image Analysis

The signal intensity of fat and effusion were similar using SSFP (p=NS) or Mag-IR (p=NS). Using PS-IR, the fat is bright (positive) but the effusion is dark (negative) (p<0.001). These findings are displayed in Figure 3. Representative images using the three sequences are displayed for all effusion sizes in Figure 4A. A patient with a large pericardial space filled with epicardial fat is visualized by each of the three sequences in Figure 4B.

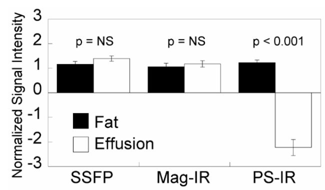

Fig. 3: Signal intensity measurements of epicardial fat and pericardial effusion normalized to blood for Steady-state Free Precession (SSFP), Magnitude Inversion Recovery (Mag-IR) and Phase Sensitive Inversion Recovery (PS-IR).

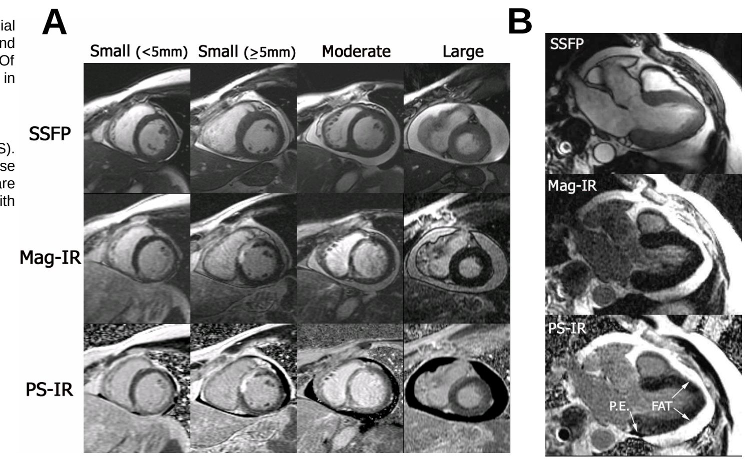

Fig. 4: Representative images for Steady-state Free Precession (SSFP), Magnitude Inversion Recovery (Mag-IR) and Phase Sensitive Inversion Recovery (PS-IR).

A: This graphic demonstrates the signal intensity difference between SSFP (top row), Mag-IR (middle row) and PS-IR (bottom row) by varying effusion size. On the SSFP and Mag-IR images, blood, epicardial fat, and pericardial effusion appear bright. The PS-IR images show a dark pericardial effusion, bright epicardial fat, and dark normal myocardium.

B: Patient with a large amount of epicardial fat in the pericardial space. Using SSFP and Mag-IR images, the material contained in the pericardial space could be fat or fluid. In the PS-IR image, a small posterior pericardial effusion (P.E.) is clearly seen and differentiated from the epicardial fat (FAT).

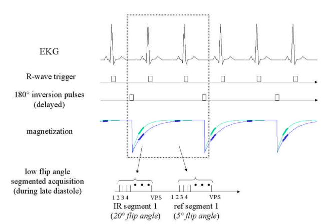

Fig. 1: Pulse sequence diagram for gated, segmented *k*-space acquisition of IR and reference images using low flip –angle readouts. Data for IR and reference images are collected alternately every other heartbeat.

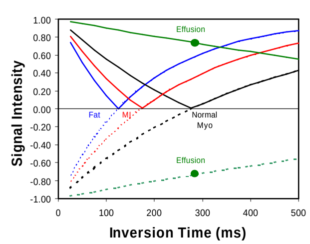

Fig. 2: Expected signal intensity on PS-IR (dotted lines) and Mag-IR images (solid lines) based on T_1 recovery curves. At an inversion time that nulls normal myocardium (275 ms) about 20 minutes after double dose contrast, normal myocardium (black line) is nulled and infarcted myocardium (MI) has high signal intensity (red line). However, at this inversion time, effusion (green line) and fat (blue line) are both bright on magnitude images. Phase sensitive images more correctly depict T_1 of pericardial effusion (dotted green line).

DISCUSSION

SSFP cine MRI and conventional gadolinium-enhanced infarct images (Mag-IR) do not adequately discriminate between pericardial effusion and epicardial fat despite the large difference in T_1. Phase sensitive reconstruction of the same gadolinium enhanced infarct images (PS-IR) provides high quality delayed hyperenhancement images and easily differentiates effusion from fat. PS-IR does not lengthen the typical exam or acquisition time compared with conventional 2RR triggered IR infarct methods [7].

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