Journal of Cardiovascular Magnetic Resonance

Meeting abstract

1098 A faster new method using sliding-slice cine for cardiac function

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from 11th Annual SCMR Scientific Sessions
Los Angeles, CA, USA. 1–3 February 2008

Published: 22 October 2008

Journal of Cardiovascular Magnetic Resonance 2008, **10**(Suppl 1):A223 doi:10.1186/1532-429X-10-S1-A223

This abstract is available from: http://jcmr-online.com/content/10/S1/A223

Introduction

In difficult patients, real-time cine balanced SSFP (bSSFP) imaging is a final option for measuring cardiac function. Real-time imaging may be obtained without breath-hold or even without cardiac gating if necessary, unlike 2D-segmented or 3D cardiac imaging. Conventionally, for rapid function assessment, real-time imaging acquires a cine of a short-axis slice in one cycle, and is repeated for the stack of short-axis slices to cover the left-ventricle. Real-time cine stack imaging typically requires two cardiac cycles per slice, because the first cycle is required for bSSFP stabilisation to avoid artefacts and also to develop blood:myocardium contrast ready to start data acquisition at the second R-wave.

Purpose

Describe a sliding-slice method for cardiac function measurement which avoids the need for stabilisation delays, compare it with existing methods and also against omitting stabilisation.

Methods

Four methods (Table 1) for cardiac function were compared in each of 5 normal subjects, at 1.5 T (Siemens Avanto). To avoid the interruptions caused by stepping to the next slice of the stack, real-time cine bSSFP ("TrueFISP") imaging was modified to run continuously and shift the slice gradually during each image (sliding-slice real-time imaging). The shift was calculated so that the slice moved 10 mm along the ventricle in the average RR interval found before starting the sequence. There was therefore no need for stabilisation cycles between the slices, so each slice cine required only one cycle to acquire. The image slice moved steadily along the entire ventricle during the breath-hold. For comparison, real-time cine imaging was acquired unmodified (2-cycle real-time imaging), and was also repeated without stabilising each slice (1-cycle real-time imaging). For reference, conventional multiple breath-hold cine bSSFP images were obtained. For each cine, the left ventricular chamber area was measured at diastole and systole, and the areas summed for end-diastolic volume (EDV) and end-systolic volume (ESV). Ejection fraction (EF) and stroke volume (SV) were calculated.

Results/discussion

Example images for all four approaches are shown (Figure 1). Without stabilisation, the 1-cycle real-time imaging showed artefacts and low contrast in the first few cine frames. The end-systolic frame was reasonably clear of stabilisation artefact, but blood:myocardium contrast did not appear to reach that of the 2-cycle approach. Diastolic volume could be measured more accurately from the last frame of the cine because the first frame already contained some cardiac contraction. The 1-cycle approach was discontinued. For the sliding-slice method, image contrast between myocardium and blood was reduced for some cardiac phases, and it is unclear how much stabilisation/magnetisation transfer, which usually darkens myocardium, occurs in this technique. A modified form of the sliding-slice might pause motion after 10 mm, awaiting the next R-wave.

Table 1: Pulse sequence parameters

	Sliding-slice real-time	2-cycle real-time	1-cycle real-time	Conventional
Resolution (mm)	2.2FE × 3.4PE	2.2FE × 3.4PE	2.2FE × 3.4PE	1.4FE × 1.4PE
R-R intervals per slice	1	2	1	8
Shared-frame	Y	Y	Y	N
Frame time (ms) incl. sharing	68 ms	68 ms	68 ms	37 ms
Parallel imaging	GRAPPA × 1.7	GRAPPA × 1.7	GRAPPA × 1.7	TSENSE × 2

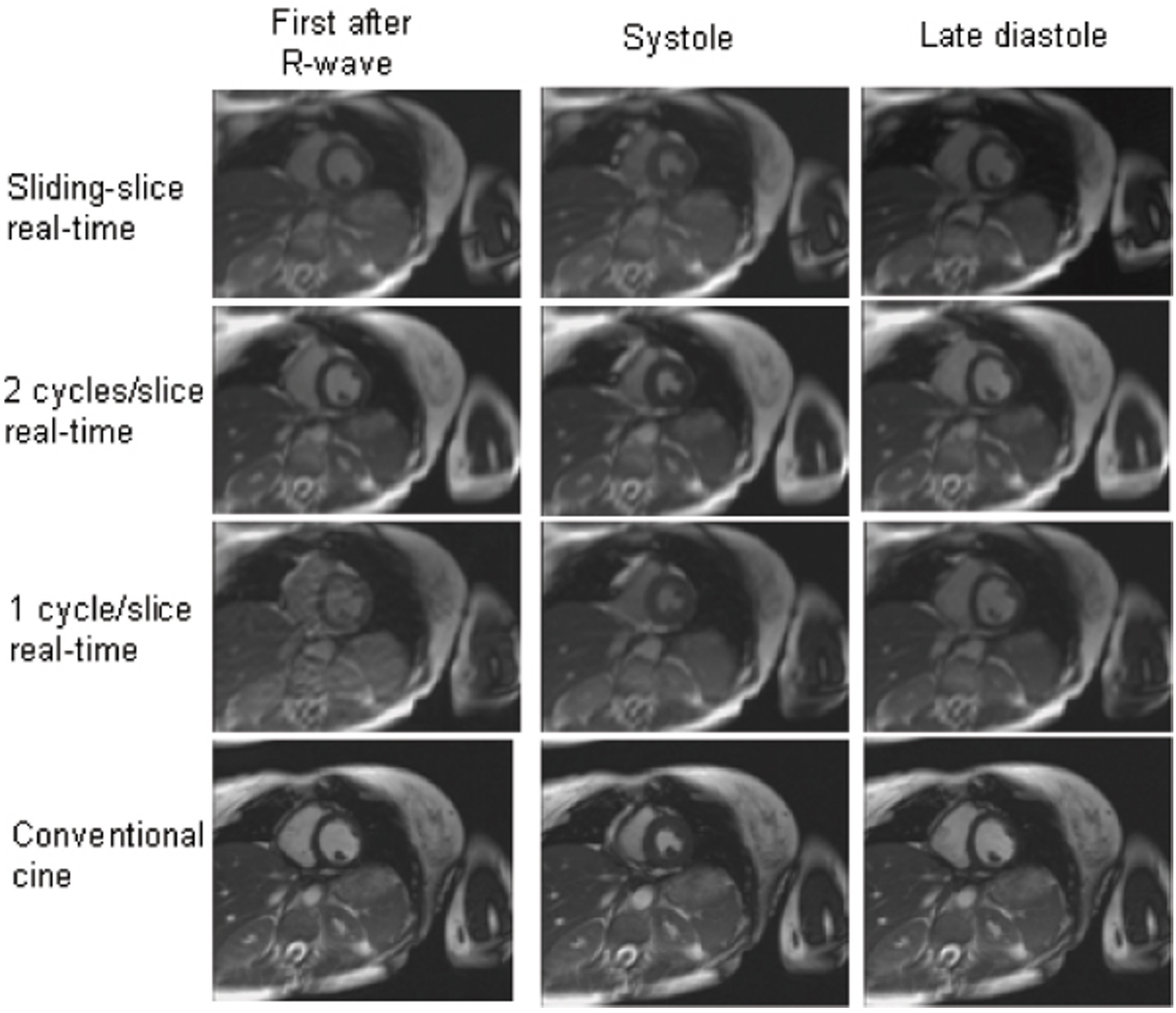

Figure 1
Real-time cine bSSFP imaging for cardiac function normally requires some stabilisation time between slices, which slows it down. Aiming for maximum speed, two approaches avoiding these delays are compared with the normal stabilised real-time cine.

Figure 2 compares real-time ventricular function measurements against conventional cine, and there is considerable scatter for both real-time approaches. (One subject was extraordinarily physically fit). The lower resolution of real-time imaging reduces its accuracy, in both temporal and spatial resolutions. Both the 2-cycle real-time

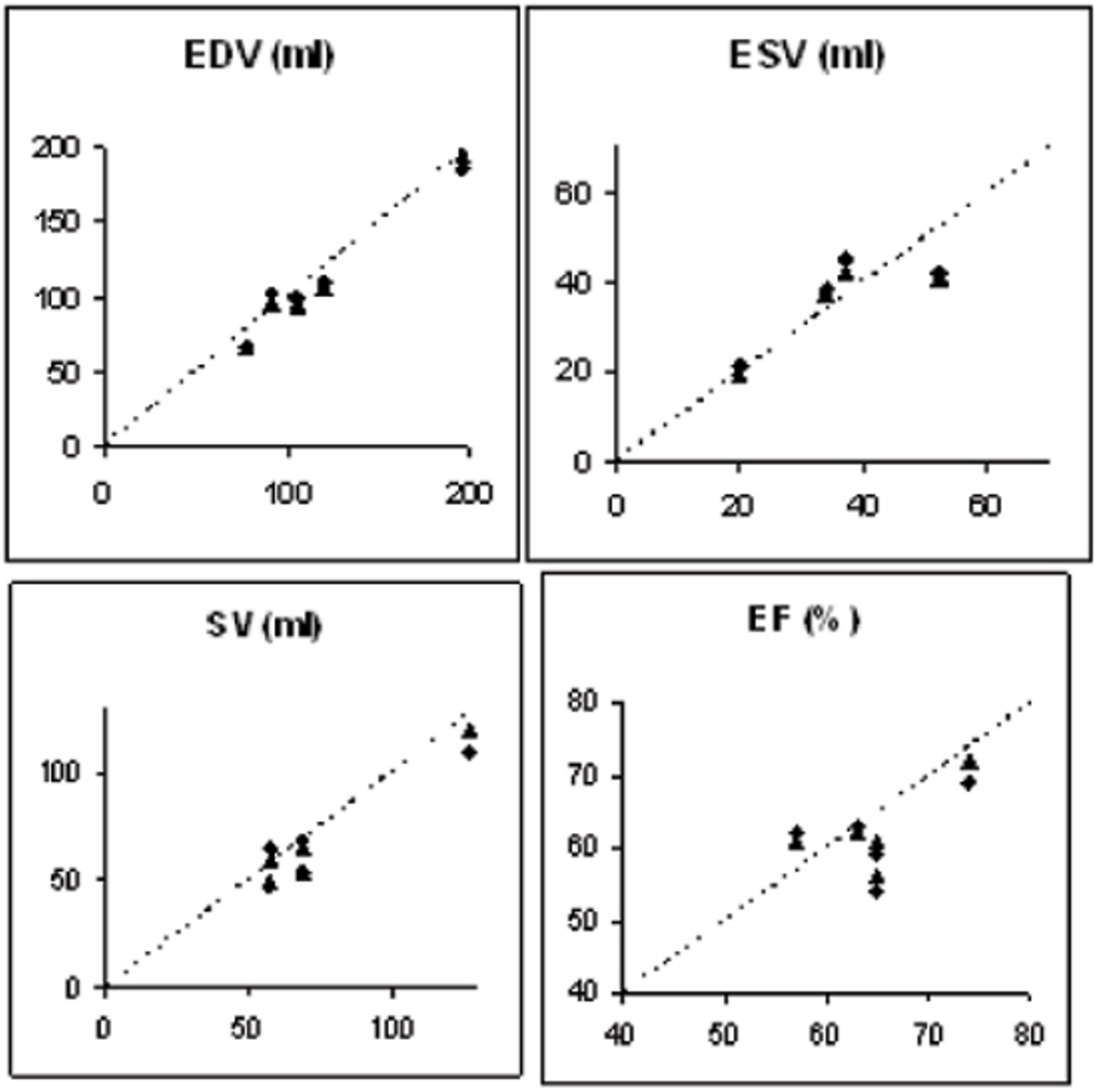

Figure 2: Triangle = 2-cycle real-time, Diamond= sliding-slice. compared with conventional cine on horizontal axis.

Figure 2
Triangle = 2-cycle real line, Diamond = Sliding-slice compared with conventional cine on horizontal axis.

approach and the sliding-slice approach performed similarly, with half the breath-hold time for the sliding-slice method. The continuous cine of the sliding-slice was limited to 128 phases by software and this obstructed its application at slow heart-rates. As a useful last resort in difficult cases, it seems unfortunate that multislice cine real-time image normally spends alternate cycles stabilising the steady-state. The sliding-slice cine sought to circumvent this inefficiency, but the gradual change in slice contents may challenge both the shared-phase and parallel imaging methods used. Surprisingly, this only sometimes generated FOV/2 artefacts.

Conclusion

The sliding-slice continuous cine enables more rapid cardiac volume acquisition, but improved blood:myocardium contrast and reduced artefacts would require further investigation.