Real-time assessment of right and left ventricular volumes and function in patients with congenital heart disease using high spatio-temporal resolution radial k-t SENSE.

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INTRODUCTION

Magnetic resonance assessment of ventricular volumes and function has become an integral part of clinical management (1). However, traditional ECG gated, breath-hold, cine imaging is limited by long acquisition times, difficulty performing multiple breath-holds, and irregular heart rate. Another approach is real-time MR imaging, which can be performed without cardiac gating or breath holds. However, these benefits come at the cost of lower spatiotemporal resolution, which may affect accuracy (2). A solution is image acceleration with radial *k-t* SENSE, which allows higher spatiotemporal resolution real-time imaging to be performed (3). The purpose of this study is to compare image quality and ventricular volumes measured using (i) a cardiac gated sequence, (ii) a standard product real-time sequence, and (iii) a radial real-time *k-t* SENSE sequence in patients with congenital heart disease.

MATERIALS AND METHODS

Forty consecutive children and adults with congenital heart disease were enrolled into this study (median age 23.7, full range 12.4-63.9yrs, 21 males, 19 females). Ventricular volume assessment was performed using; (i) a Cartesian 2D, multi-slice, retrospectively cardiac gated, SSFP sequence (spatial resolution 1.8x1.8x10mm, temporal resolution 40ms), (ii) a standard Cartesian real-time 2D multi-slice SSFP sequence accelerated with GRAPPA (spatial resolution 2.7x3.3x10mm, temporal resolution 80ms, R=2) and (iii) a radial real-time 2D multi-slice SSFP sequence accelerated with *k-t* SENSE. (spatial resolution 2.3x2.3x10mm, temporal resolution 40ms, R=8)**.** Global image quality and motion fidelity was scored and compared with a Wilcoxon sign rank test. Image contrast, edge sharpness and summed perimeters were quantified, and compared using paired t-tests. Ventricular volumes were compared with paired t-tests.

RESULTS

Global image quality (Figure 1), motion fidelity (Figure 2), image contrast, edge sharpness and summed perimeters were all greater for radial real-time k-t SENSE compared to standard real-time ($p<0.05$). However, the gated acquisitions were still superior to radial real-time k-t SENSE ($p<0.05$). Mean ventricular volumes and ejection fraction measured using the three techniques are shown in table 1. For cardiac gated versus radial *k-t* real-time acquisitions, there was no statistical difference between RV volumes and ejection fraction ($p>0.15$). There was however a small difference in LVEDV and thus, LVSV and LVEF, which did reach statistical significance ($p<0.05$). For cardiac gated versus standard real-time acquisitions, both RV and LV EDV and thus, SV and EF were significantly underestimated ($p<0.05$). For radial *k-t* versus standard real-time acquisitions only RVEF and LVEF were significantly different ($p<0.05$).

DISCUSSION

Although real-time imaging has many benefits, its lower spatio-temporal resolution has hindered its use in the clinical environment. This has been particularly true in patients with congenital heart disease as the more difficult to segment RV, is often the ventricle of interest. We have shown that radial *k-t* real-time allows accurate quantification of ventricular volumes and function in patients with congenital heart disease. In addition, image quality is superior to standard real-time, allowing better assessment of anatomy and motion. This opens up the possibility of performing a complete real-time exam in patients with congenital heart disease. This would be particularly useful in patients who are unable to hold their breath (i.e. paediatric patients), or have rhythm irregularities that compromise gated imaging.

Table 1. Mean right ventricular (RV) and left ventricular (LV) end diastolic volume (EDV), end systolic volume (ESV), stroke volume (SV) and ejection fraction (EF) measured using cardiac gated images, radial *k-t* real-time and standard real-time. Radial *k-t* or standard real-time values that are significantly different from cardiac gated images are denoted by *. Standard real-time values that are significantly different from radial *k-t* values are denoted by †.

	Cardiac gated	*Radial k-t real-time*	*Standard real-time*
RVEDV	202.7±74.2 ml	200.2±76.1 ml	195.4±78.1 ml *
RVESV	91.2±47.6 ml	91.4±51.5 ml	91.2±45.6 ml
RVSV	111.5±41.2 ml	108.8±39.3 ml	104.2±45.1 ml *
RVEF	56.1±9.8%	55.9±10.1%	53.8±9.0% *†
LVEDV	139.0±35.3 ml	133.3±33.3 ml *	132.0±34.7 ml *
LVESV	52.1±20.4 ml	51.8±20.0 ml	53.1±20.8 ml
LVSV	86.9±20.5 ml	81.5±19.7 ml *	78.8±23.0 ml *
LVEF	63.4±7.4%	62.2±8.2% *	60.1±7.8% *†

Figure 1. Representative Short axis images a) Gated end-diastole b) Gated end-systole c) Radial *kt*-SENSE end-diastole d) Radial *kt*-SENSE end-systole e) Real-time end-diastole d) Real-time end-systole.

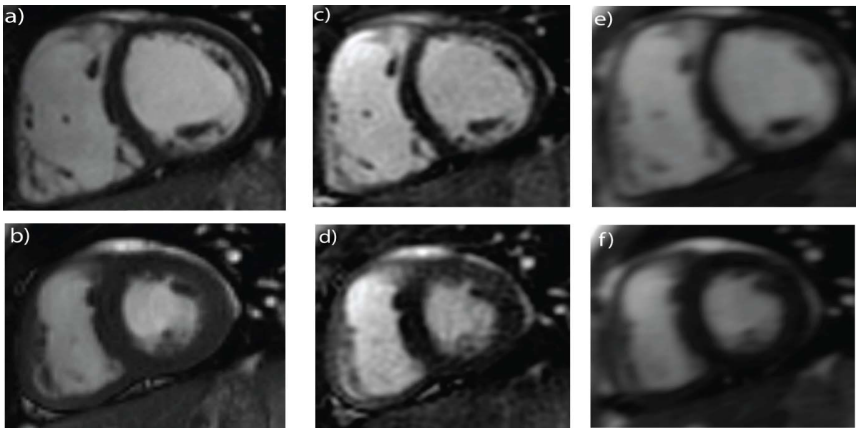
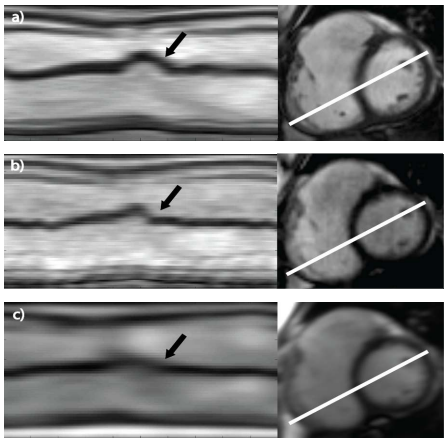


Figure 2. Pixel profile of a line through both ventricles plotted as a function of time. a) cardiac gated b) radial k-t SENSE and c) standard real-time.



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