RV Function from Cine MRI Using Contour Propagation

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INTRODUCTION

Measurement of the time dependence of ventricular volumes in cine cardiac MRI allows a sensitive assessment of cardiac systolic and diastolic function, but standard techniques for this are laborious and time-consuming. This abstract presents a method for computing volume-versus-time curves (VTC) and peak filling and ejection rates from standard cine cardiac MRI. The method uses RV contours drawn semi-automatically near end-diastole (ED) and end-systole (ES) to compute functional parameters such as RV volume, mass, and ejection fraction (EF) [1]. These contours are propagated to the remaining time frames via a non-rigid registration technique [2]. The propagated contours are validated by comparing them to contours manually drawn by a cardiologist with Level 3 training. In addition, peak ejection and filling rates computed from both manually-drawn and propagated contours are compared.

METHODS

Nine normal human volunteers were imaged on 1.5 T GE MRI system with an SSFP sequence with the following parameters: TR 3.8 ms, TE 1.6 ms, slice thickness 8mm, no inter-slice spacing, flip angle 45 deg, k-space segmentation, 10 views per segment, typical acquired temporal resolution < 40 ms, matrix 256x128, field of view 42 cm, 1 signal average, bandwidth 125kHz.

RV contours were drawn semi-automatically with manual correction at all frames for all short axis slices by a cardiologist with Level 3 training. The ED and ES contours were also automatically propagated to the remaining time frames in the sequence by the method described in [2]. RV volume-versus-time curves (VTC) were then computed from both the manual and propagated contours. The projected motion of RV tricuspid annulus along the direction perpendicular to short axis plane was used to determine weighting factors for basal short axis slices in the RV volume computation. Portions of the RV outflow tract near the base of RV that were not contiguous with rest of the RV were excluded from the volume computation. This portion of RV contributes only a minor fraction to RV EF. The VTC curves were normalized to the ED volume (EDV). Peak RV ejection and filling rates were then computed from each VTC. The peak ejection and filling rates from manual and propagated contours were compared using correlation analysis, Bland-Altman analysis, and a paired t-test.

RESULTS AND DISCUSSION

Figure 1 shows a typical result on a mid-ventricular slice near mid-diastole. The frame is depicted as it is the most distal from the manual contours at ED and ES. Good agreement was observed between the manual and propagated contours. Fig. 2 show the VTC's of all 9 studies. Both figures show good agreement between manual and propagated contours. A quantitative comparison of peak filling and ejection rates is shown in Table I. No statistically significant differences were found between ejection and filling rates computed from manual and propagated contours. In addition, all three rates showed excellent correlation between manual and propagated contours (PER: 0.86, P=0.003, ePFR: 0.98, P<0.0001, aPFR: 0.998, P<0.0001). A distinct mid-diastolic diastatic phase is noted on VTC in 7 of the 9 normal volunteers studied. Moreover, the atrial phase may be contributing to up to 20% of RV volume under normal hemodynamic conditions.

CONCLUSION

We describe a simple and accurate method for propagating short-axis myocardial RV contours semi-automatically drawn at ED and ES, enabling accurate evaluation of RV systolic and diastolic function. This semi-automated method allows detailed assessment of the major measures of global RV systolic (PER) and diastolic (ePFR, aPFR) function, and requires only limited user input. We demonstrate presence of a period of mid-diastolic diastasis phase followed by significant contribution of right atrium to RV function under normal hemodynamic conditions.

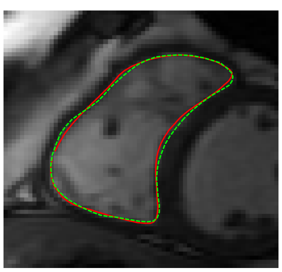

Fig.1. manual (solid red) and propagated (dashed green) RV contours for a mid-ventricular slice at mid-diastole.

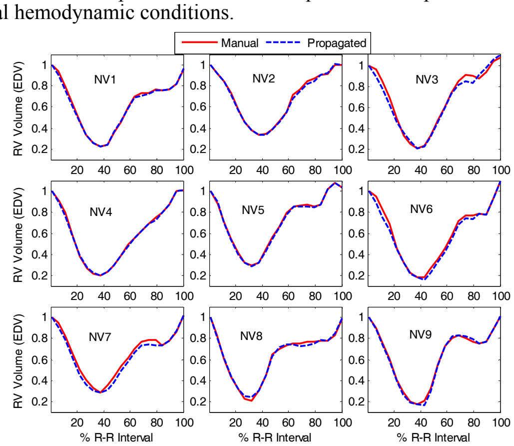

Fig.2. RV volume-vs-time curves from manual and propagated contours for 9 normal human volunteers.

Table I. Comparison of RV peak ejection (PER), early diastolic filling (ePFR), and atrial diastolic filling (aPFR) rates computed from manual and propagated contours. Limits: Bland-Altman limits of agreement.

	Manual	Propagated	P	Limits
PER (EDV/s)	3.59±0.19	3.40±0.15	0.12	-0.43 to 0.80
ePFR (EDV/s)	2.72±0.21	2.66±0.25	0.34	-0.28 to 0.39
aPFR (EDV/s)	2.13±0.21	2.13±0.21	0.81	-0.08 to 0.07

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