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Single breathhold, three-dimensional measurement of left atrial volume and function using sparse CINE CMR imaging with iterative reconstruction

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Background

Left atrial (LA) dilatation is associated with a large variety of cardiac diseases and many LA pathologies go along with an adverse prognosis. A time-efficient 3D CMR method to precisely measure the LA volumes and function is therefore highly desirable.

Methods

A highly accelerated prototype cine sequence with sparse sampling and Iterative Reconstruction (sCINE-IR) was used in phantoms and patients to acquire 5 cine slices (2 long axis, LAX and 3 short axis, SAX) through the LA during a single breathhold yielding a spatial/temporal resolution of 1.5mm/30ms (1.5T Aera, Siemens AG, Germany). The LA volumes were reconstructed from these 5 slices using a non-model based method (Bermano A, ACM trans Graph 2011). As a reference in patients, a self-navigated high-resolution whole-heart 3D dataset (3D-HR) was acquired during mid-diastole, from which the LA volume was segmented. Phantom study. Five LA phantoms made of solanum tuberosum L of known volume (water displacement method) and of different shapes were imaged with both 3D-HR and CS in various slice orientations and the calculated volumes were compared. Patients study. Three patients were scanned with both 3D-HR and sCINE-IR. The volumes obtained with 3D-HR and with sCINE-IR during the corresponding mid-diastolic frame were compared using Bland-Altman method and linear regression.

Results

Phantom study. Volumes measured by sCINE-IR were highly correlated with the true LA volume, with a mean difference of -4.7±1.8ml (8.7% underestimation, R^2=0.94). The calculated volumes were not significantly different when different orientations of the sCINE-IR slices were planned (LAX aligned vs not aligned with the true LA long axis, SAX parallel vs not parallel to the mitral plane, p=ns for both). The mean difference between 3D-HR and true LA volume was -1.4±1.4ml (2.3% underestimation, R^2=0.97). Patients study. Reference LA volumes were obtained with 3D-HR in 3 patients aged 23-80 years (63ml, 62ml and 395ml). sCINE-IR -calculated volumes of the mid-diastolic frame matched closely the reference volume with a difference of 2.7±6.5ml (2.7% underestimation, R^2=0.99). Complete time-volume curves of the LAs were obtained for each patient, allowing to assess LA phasic function (Figure).

Conclusions

With this new method of a highly accelerated sCINE-IR acquisition followed by a 3D non-model based reconstruction, LA volumes could be accurately measured from 5 cine slices acquired during one single breath

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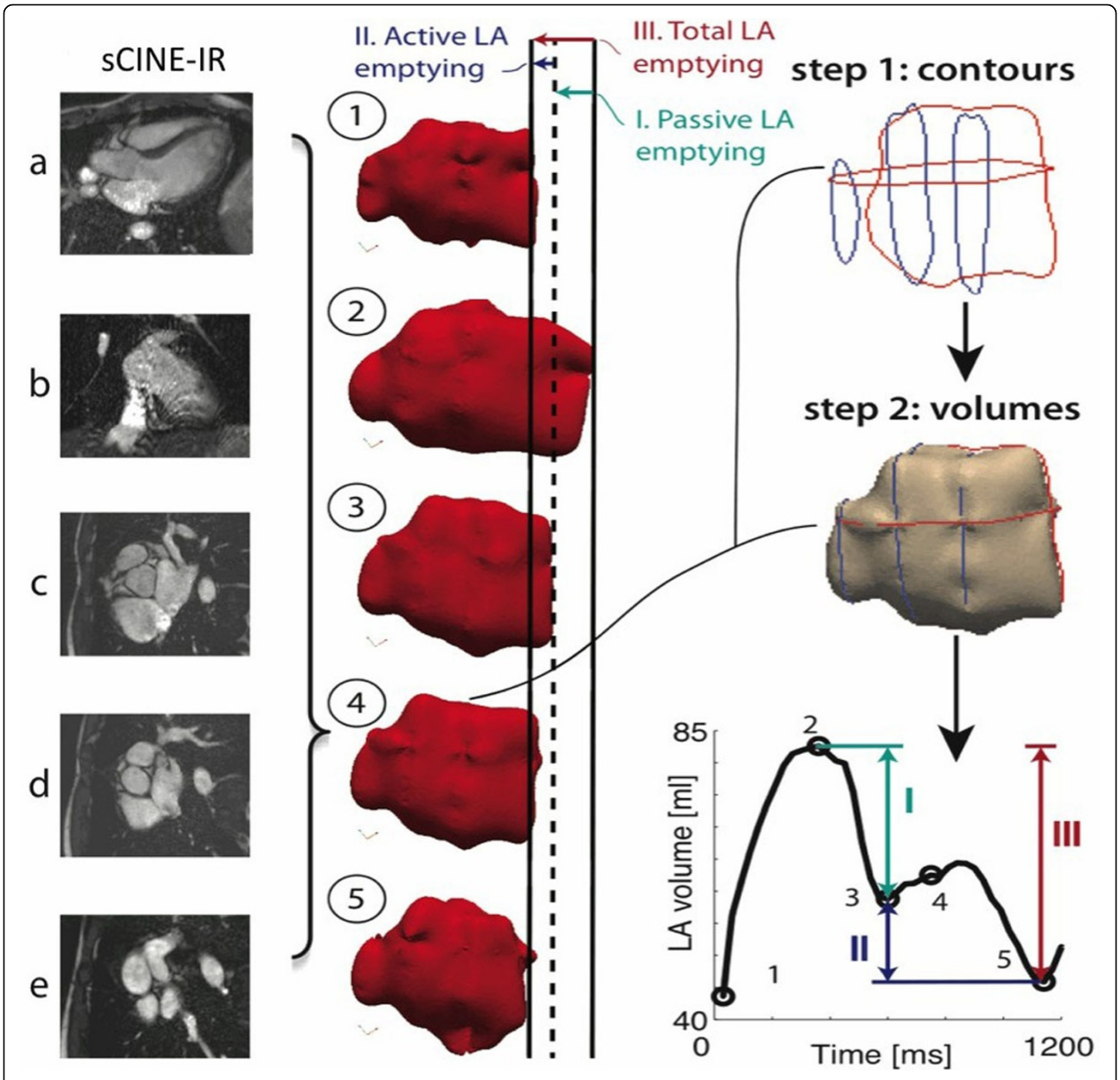

Figure 1 LA volume reconstruction using a sCINE-IR acquisition. Left : sCINE-IR acquisitions through the LA. Images a and b correspond to SAX and images c,d and e to SAX. Middle : the 3D-reconstructed LA volumes (red casts) are shown at 5 different time points during the cardiac cycle, oriented perpendicular to the mitral valve to illustrate the mitral valve motion and lengthening and shortining of the LA long axis. Right : figure at the top illustrates the 5 contours at time point 4, used to reconstruct the LA volume at time point 4 (center right). At lower right, the LA volume curve is given over the entire cardiac cycle (I=LA passive emptying volume; II=LA active emptying volume; III=LA total reservoir volume)

hold. This method opens the possibility to precisely measure LA function over time. The reproducibility of this new technique needs to be assessed on a larger patient cohort.

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