3D kat ARC cine for evaluating cardiac function on 3T

Shigeo Okuda[1], Yoshitake Yamada[1], Akihiro Tanimoto[1], Jun Fujita[2], Motoaki Sano[2], Keiichi Fukuda[2], Sachio Kuribayashi[1], Atsushi Nozaki[3], and Peng Lai[4]

[1]Diagnostic Radiology, Keio University School of Medicine, Tokyo, Japan, [2]Cardiology, Keio University School of Medicine, Tokyo, Japan, [3]MR Applications & Workflow, GE Healthcare, Hino, Japan, [4]MR Applications & Workflow, GE Healthcare, Menlo Park, CA, United States

Introduction:

3D cardiac cine imaging using k-t acceleration techniques have been reported on 1.5 Tesla scanners[1-7]. Recently, kat ARC (k-& adaptive-t-space data synthesis - autocalibrating reconstruction for Cartesian sampling - based technique (ARC)) was developed for 3D cardiac cine imaging[8,9] within a single breathhold. For kat ARC, k-space data were acquired with time-shifted sampling and missing k-space data were recovered using a k-t synthesis kernel with temporal window selection adaptive to local cardiac motion at each cardiac phase. The purpose of this study is to evaluate the reliability of kat ARC whole-heart cine imaging for the evaluation of cardiac function on 3T.

Material and Methods:

The protocol of this study was approved by the institutional ethics committee, and written informed consent was obtained from all patients. All imaging was obtained on a 3 Tesla clinical scanner (Discovery MR750, GE healthcare) with 32-channel cardiac coil. A total of twenty-one patients with cardiac disease (twelve men, mean age = 59.4, mean BMI = 23.3 kg/m^2) were enrolled in this study. Retrospective electrocardiogram (ECG) – gated 2D SSFP cine images were acquired with parameters as follows: TR/TE = 3.5/1.5 ms, matrix size = 224×224, flip angle = 45˚, acceleration factor = 2 in the left ventricle (LV) short axis, scan time of 17~22 sec within 9 ~15 consecutive breathholds. Immediately after the acquisition of 2D cine, retrospective ECG-gated 3D kat ARC cine images were obtained with parameters of TR/TE = 2.8/1.5 ms, matrix size = 180×210, flip angle = 40˚, net acceleration factor = 7.7, scan time of 18 sec in one breathhold. ~18 slices, slice thickness of 8 mm without gap, field of view of 38 cm, and band widths of 125 kHz were used for both imaging techniques. No contrast material was used before either 2D cine or 3D cine scans.

Both 2D and 3D cine images were transferred to a separate workstation (AdvantageWorkstation, GE healthcare) and a software 'MassAnalysis' was used for volumetry of LV. Two radiologists reviewed cine loop and defined end-systolic and end-diastolic phases. The endocardial and epicardial contours were manually traced on end-diastole (ED) and end-systole (ES). Papillary muscles and trabeculations were included in LV volume. Then, LV ED volume (LVEDV), LDESV, LV stroke volume (LVSV), LV ejection fraction (LVEF) and the weight of LV (LVmass) were calculated. The observers performed a second measurements with more than four weeks interval after the first measurement to analyze the intra-observer variability.

The correlation between parameters calculated from 2D and 3D cine images was analyzed by Pearson's correlation. Bland-Altman's analysis was performed to observe the interchangeability between parameters between 2D and 3D cine images. The inter- and intra-observer variability was revealed by using r values in Pearson's correlation.

Results:

The image of one patient was excluded from the analysis due to low contrast between the LV cavity and the myocardium in 3D cine. Therefore, the comparative study was performed in 20 patients. Fig.1 shows a representative case. The correlation coefficient of each parameter between 2D and 3D cine had good correlation with r value of more than 0.97. The bias of all parameters was small, and 95% of limit of agreement was clinically acceptable as follows: ±8.86 mL, ±5.94 mL, ±8.55 mL, ±3.62%, ±8.69 g for LVEDV, LVESV, LVSV, LVEF and LVmass, respectively (Fig.2). The inter- and intra-observer difference had good correlations. All r values were equal or more than 0.97, excluding inter-observer difference of 3D SV which had r value of 0.93.

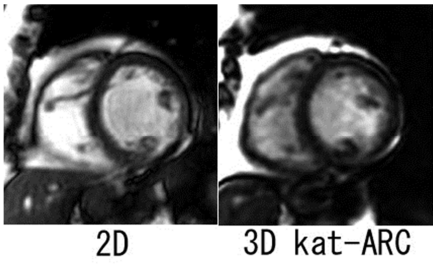

Fig 1. 2D and 3D kat ARC cine

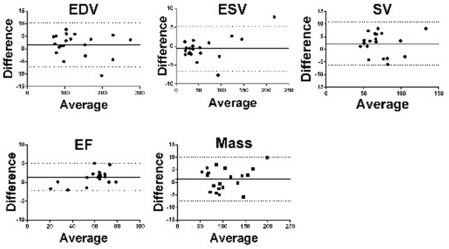

Fig 2. Bland-Altman's plots between functional parameters obtained from 2D and 3D cine

Discussion:

Whole-heart 3D cine was successfully acquired during one breath-hold in 18s, which will improve the accessibility of the patients with cardiovascular disease for cardiac MR studies. In the current study, kat ARC technique successfully acquired 3D cine images which can provide cardiac functional parameters with high interchangeability with the conventional 2D cine. 3D cine images in general show lower blood chamber-myocardium contrast compared to 2D cine, presumably due to reduced inflow blood enhancement with volumetric excitation. But the contrast of 3D cine was sufficient for drawing LV cavity contours on most patients except one. The turbulence of blood flow in the aortic root affected the image quality in the basal slices in some cases. While 2D cine performs slice-by-slice shimming, 3D cine requires shimming of the entire heart volume and therefore is more susceptible to susceptibility-induced SSFP banding artifacts.

Conclusion: 3D kat ARC cine enables accurate clinical evaluation of cardiac function within a single breathold, which can shorten the exam time and improve patient's acceptability to CMR.

References: 1. Tsao J. MRM 2003;50:1031-42.
2. Jahnke C. JMRI 2007;25:737-42.
3. Amano Y. Comput Med Imaging Graph 2008;32:61-6.
4. Greil GF. JMRI 2008;27:510-5.
5. Huber S. MRI 2008;26:727-38.
6. Maffei E. Insight Imaging 2011;2:39-45.
7. Jaroni J Academic Radiology 2013;20:987-94.
8. Lai P. Proc Intl Soc Mag Reson Med 2009;17:767.
9. Lai P. Proc Intl Soc Mag Reson Med 2011;19:3378.