Comparison of Cardiac MR and 3D Echocardiography Left Ventricular Analysis

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Introduction

Patients diagnosed with cardiac pathology may benefit from readily available follow-up examinations. A commonly used parameter to describe cardiac function is the left ventricular (LV) ejection fraction (EF). After initial diagnosis with cardiac MRI (CMR), which is considered the golden standard, real time 3D echocardiography (3DE) could be used as a follow-up, provided its results prove to be both reproducible and directly comparable with CMR.

Recent literature [1,2,3,4] reports similar EF values, while 3DE underestimates both end-diastolic (EDV) and end-systolic (ESV) LV volumes. However, all these studies report large total error margins due to inhomogeneous patient groups, as shown in figure 1. Paired data from individual patients is needed to determine the sources of error.

Therefore, the goals of this study were to determine the intrinsic reproducibility of CMR and 3DE and to test the comparability of EF and LV volumes yielded by various dedicated software packages.

Figure 1 – Typical ejection fraction values including reported standard deviations from previous studies reported in literature

Methods

Intrinsic reproducibility was determined by acquiring multiple ECG-gated CMR and 3DE dataset from two healthy volunteers. Twenty patients (14 men, mean age 53 years, range 26-73) were included into the study with no serious cardiac function impairment (cardiomyopathy or arrhythmia), they underwent ECG-gated CMR examination (Philips Intera Nova 1.5T) and consecutive 3DE follow-up (Philips iE33) in which three datasets were acquired. Each acquisition contained 3 radial long axis (LA) cine images (B-TFE, TR=3.31±0.06ms, TE=1.66±0.03ms) and a stack of 12 short axis (SAx) cine images (TR=3.47±0.07ms, TE=1.74±0.03ms, no slice gap), matrix size 256x256 and a FOV of 40cm. One slice was acquired per end-exhalation breath hold. All examinations and planning were performed by the same technician to minimize variability. All 3DE data was acquired with the volunteers in the left lateral decubitus position and a standard breath hold protocol, and all acquisitions were again performed by one sonographer.

Analysis: CMR data was analyzed by two observers with CAAS MRV v4.2 semi-automatic method (PieMedical Imaging) and 4D-LV MR Analysis 1.0 (TomTec GmBH, volunteers only). All 3DE data was analyzed twice by the same observers with 4DLV Analysis v2.6 (TomTec GmBH) and 3DQLab Advanced v6 (Philips Healthcare). The volunteer data was analyzed multiple times (5+) with the four software packages.

Results

Results from the repetitive measurements on the healthy volunteers are shown in table 1. It shows both CMR packages provide highly reproducible results compared to the 3DE packages and LV volumes are underestimated by 3DE, particularly EDV.

Results from the patient study are shown in figure 2. For all patients, EDV and ESV were significantly higher for

Table 1 – Results from volunteer study. Displayed value is the mean of all observations of both observers (up to 80 observations), the standard deviation and the relative error as a percentage.

	3DQlab (3DE)		Tomtec (3DE)		Tomtec (CMR)		CAAS (CMR)	
EDV (ml)	127 ± 10	(8,0%)	133 ± 10	(6,5%)	167 ± 4	(2,5%)	190 ± 5	(2,5%)
ESV (ml)	46 ± 6	(11,8%)	64 ± 8	(11,1%)	57 ± 2	(3,9%)	73 ± 3	(4,0%)
EF (%)	47 ± 4	(8,0%)	51 ± 3	(6,6%)	66 ± 1	(1,9%)	61 ± 2	(2,8%)

CMR (167±28 mL and 68±22 mL) than for 3DE (127±31 mL and 63±19 mL), which corresponds to current literature. The EF was also higher; 59% for CMR and 51% for 3DE. Typical image quality is shown in figure 3. ANOVA analysis of the data indicated results for CMR are only influenced significantly by the software package and the observer that uses it (systematic errors), while for 3DE results depend on the acquisition as well. CMR software packages are very precise and reproducible, but their accuracy is not confirmed, since Tomtec MR and CAAS produce different results.
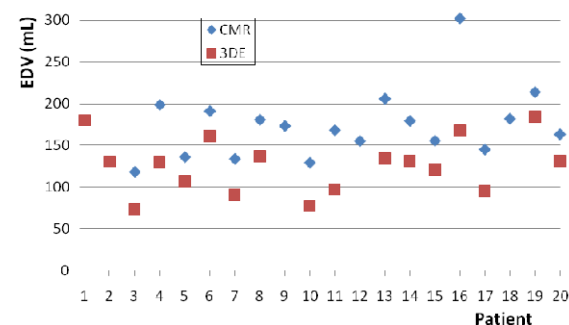

Figure 2 – EDV results from the group of 20 patients, with CMR EDV being significantly higher in every instance. ESV and EF were also slightly higher.

Discussion

Although reproducibility of 3DE is lower the CMR, this study confirms it can be used as a follow-up to CMR. 3DE variability is lower than conventional 2D echocardiography and, as such, it provides an valuable assessment of cardiac function performance.

It should be noted that the choice of software package impacts the results, so when used in conjunction with 3DE packages, the results are not directly comparable. Also, observer-related differences may occur as the software algorithms allow interpretations made by the observer on the choice of LV boundaries.

Future work will be the addition of multislice CT and/or SPECT as extra comparison or the calibration of all modalities with a multimodality phantom study.

References

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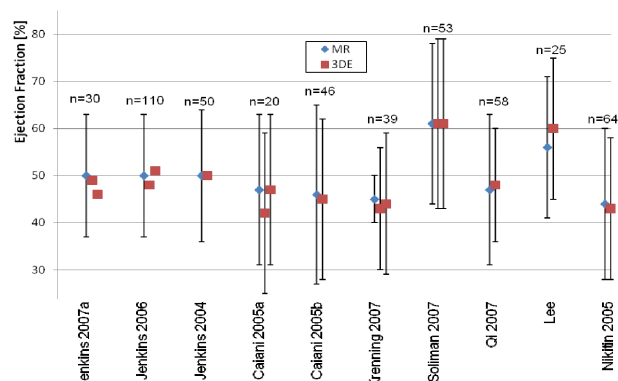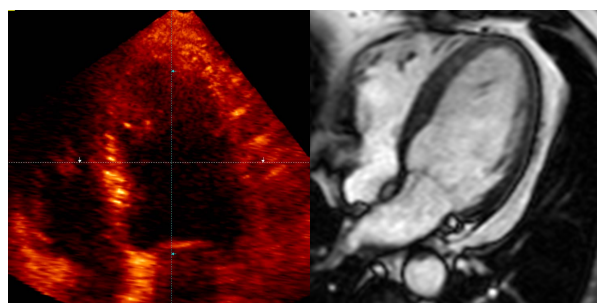
Figure 3 – Long axis 4 chamber view, typical 3DE dataset and a corresponding CMR image of the same patient