3D Color-Doppler Echocardiography and Chronic Aortic Regurgitation: A Novel Approach for Severity Assessment

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There is no conflict of interest

Background

Aortic regurgitation (AR) represents an important cause of morbidity and mortality in the general population

Clinical evaluation but most importantly **AR severity assessment** is essential to define best therapeutic strategy

Routine 2D echocardiography shows some limitations in AR severity assessment

Background

3D echocardiography allows an accurate evaluation of the aortic root structures overcoming some of the 2D echocardiography limitations

3D colour evaluation might improve the accuracy of functional regurgitant orifice measurement

3D matrix array probe allows 3D colour doppler (3DCD) rendering and the new analysis software makes the process faster and ready for its use in clinical practice

Aim

To evaluate the accuracy of current 2D echo-Doppler methods and 3DCD echocardiography for the assessment of chronic AR severity compared to cardiac magnetic resonance (CMR) quantification of AR severity

Methods

Study population

32 consecutive patients with CAR studied in the Cardiac Imaging Unit

Exclusion criteria: more than mild valvular heart disease different than AR, congenital heart disease, presence of cardiomyopathy and patient refusal to participate in the study

2D and 3D echocardiography were performed the same day

CMR was performed within 15 days from the echocardiographic study

Methods

2D echocardiography

iE33, S 5-1 probe

Conventional M-mode, 2D echo, pulse and continuous spectral doppler and colour doppler were obtained.

3 cardiac cycles and average (atrial fibrillation, 5 cycles)

Jet width and vena contracta measured from M-mode and 2D colour doppler

Volumetric method for regurgitant volume (RV)and regurgitant fraction (RF)

Zoghbi WA et al J Am Soc Echocardiogr. 2003 ;16:777-802
Lang R. Eur J Echocardiography 2006; 7, 79-108

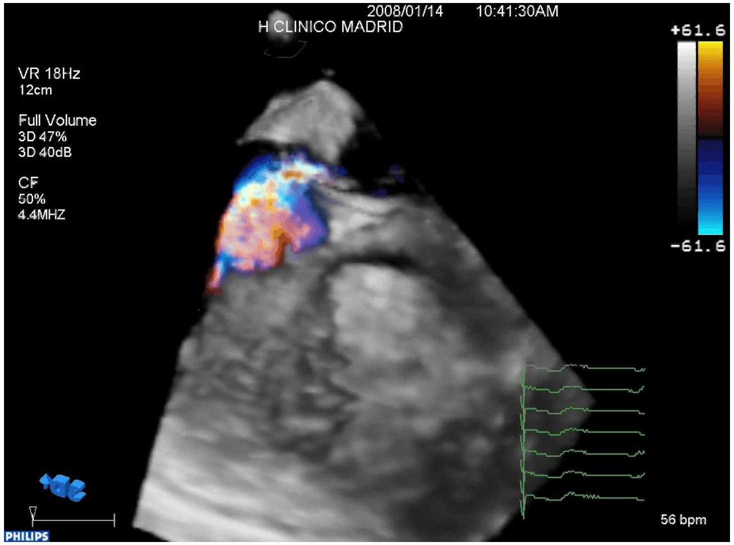
Methods

3D echocardiography

iE33, X3-1probe

3D full volume for LV volumes and LVEF analysis

3DCD was performed by placing the region of interest in the aortic valve area from an apical view. Settings optimized for colour doppler resolution



Methods

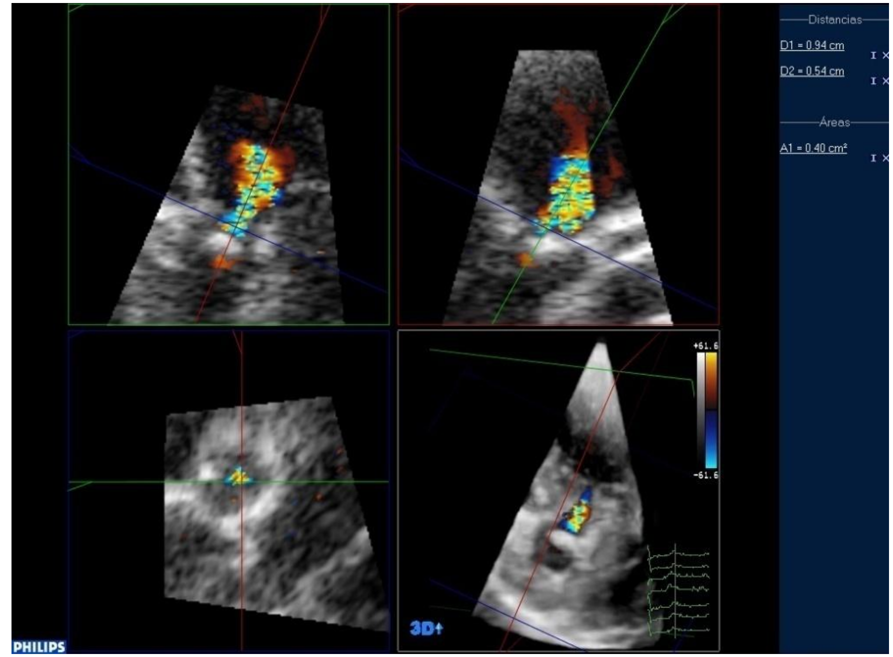
3D echocardiography

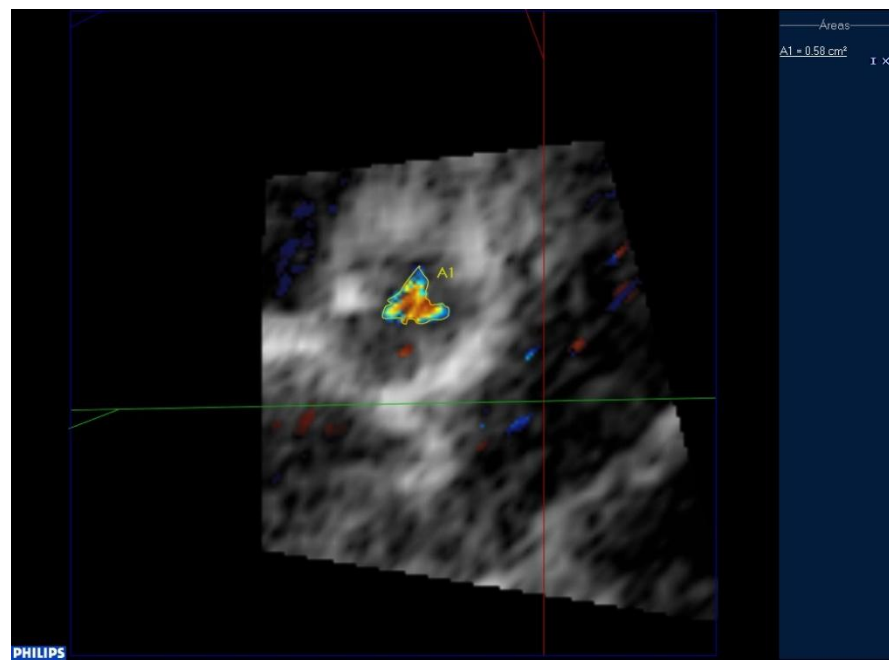
Off-line analysis, Q-Lab®

LVOT and AR vena contracta measurements were performed

"en face" at the ideal cross section, inmediately below the aortic valve lane in mid diastole

3DQ-Advance software LV volumes and ejection fraction calculations





Methods

Cardiac magnetic resonance (CMR)

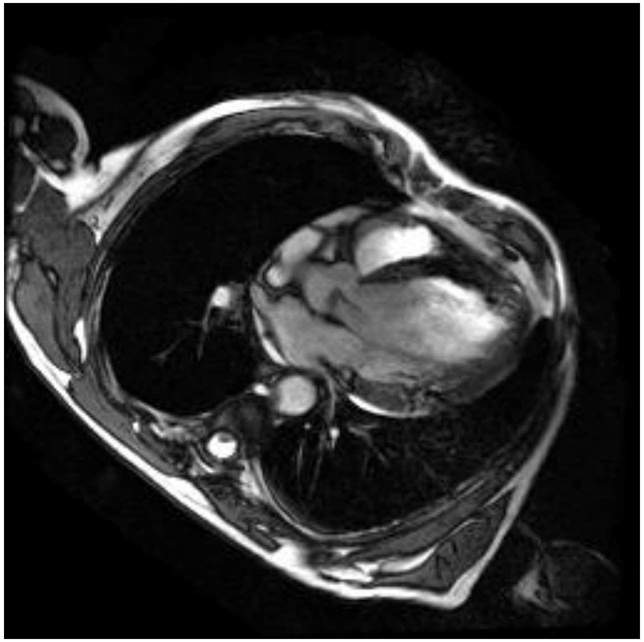
1,5 T scanner,

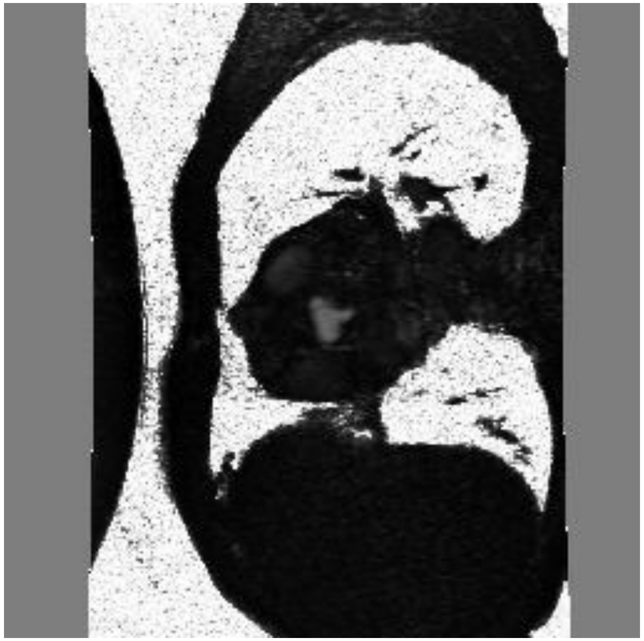
8 channel surface cardiac coil

Retrospective EKG gating

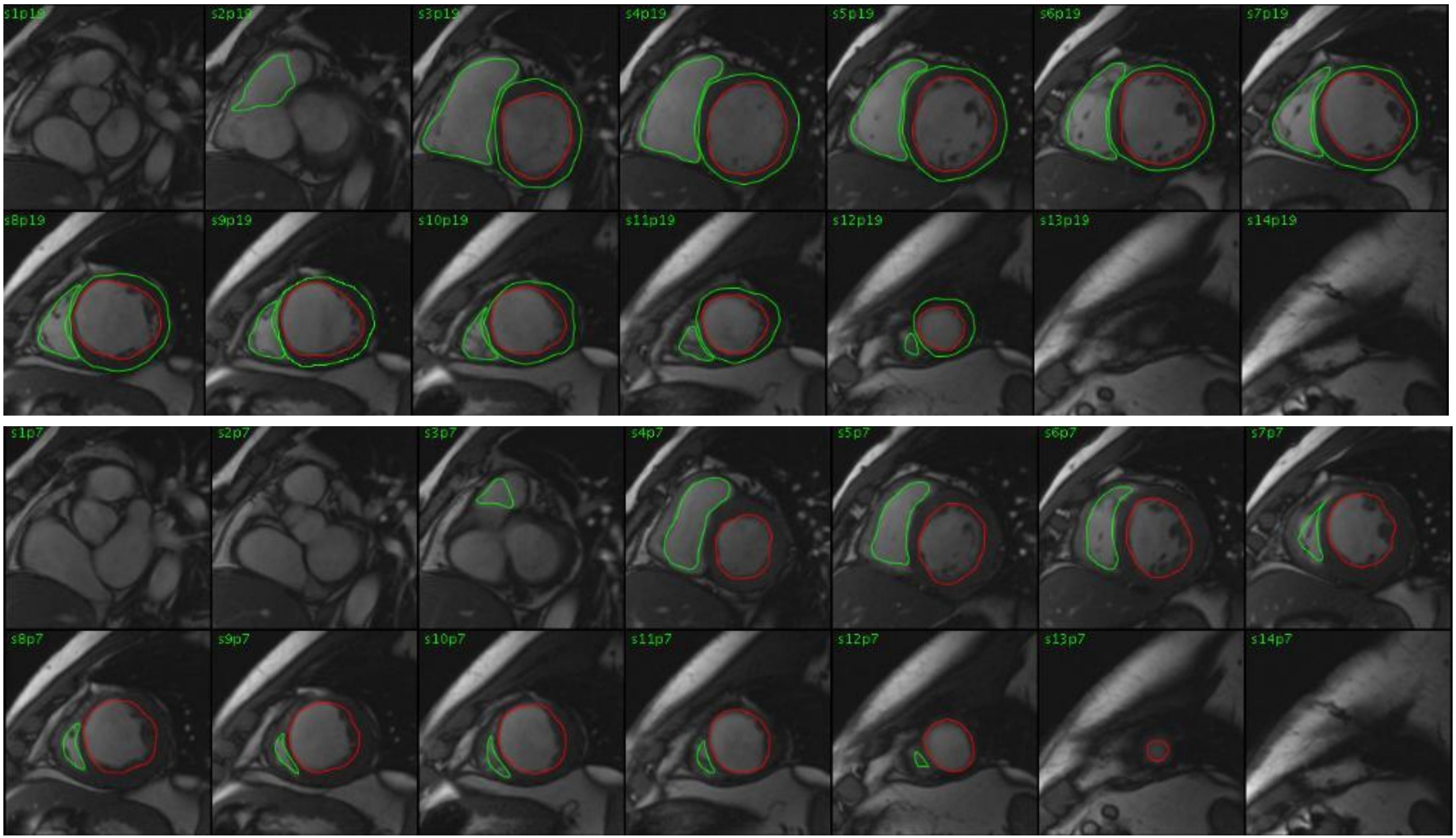
Breath hold gradient echo sequence (SSFP)

Breath hold ECG gated phase contrast velocity sequence perpendicular to the aortic valve, jus above the aortic annulus



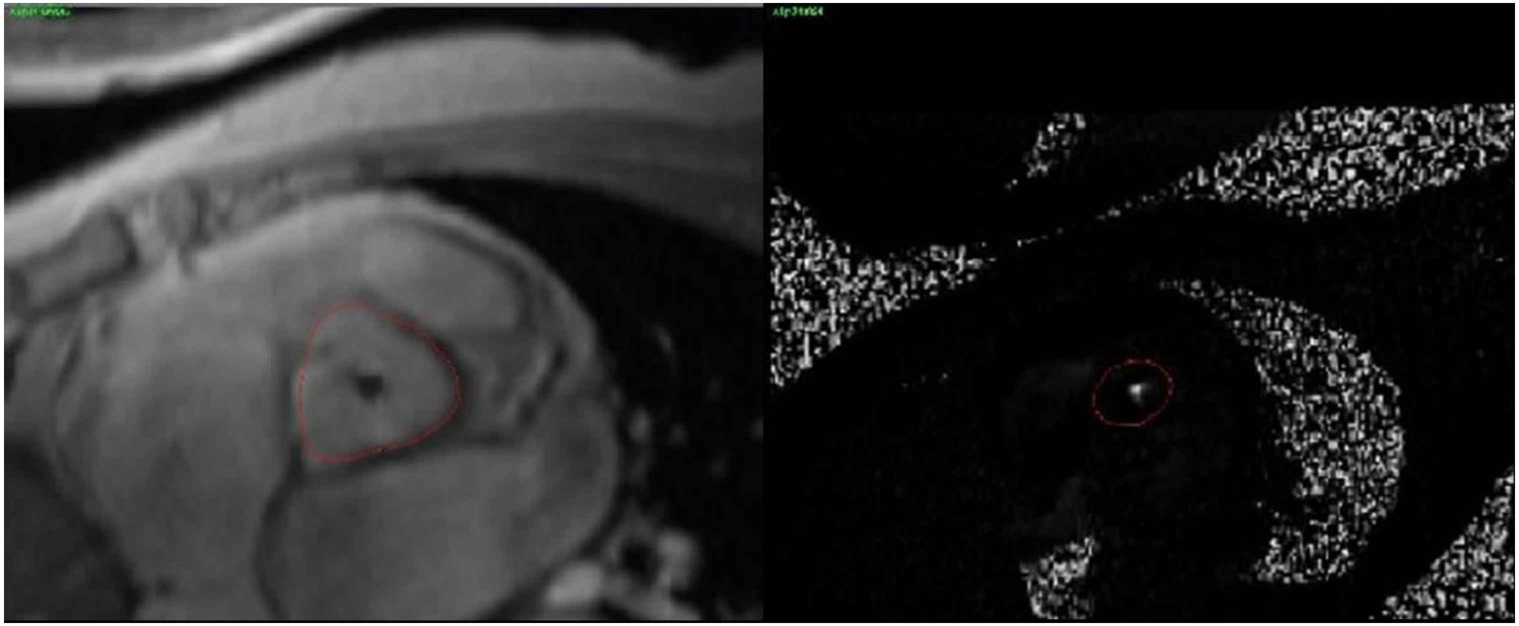


Methods



Report Card 2.0

Methods



Methods

Cardiac magnetic resonance (CMR)

AR RV: diastolic reversal volume from the aortic flow curve

AR RF: regurgitant volume/ forward aortic flow x 100

Severity	Mild RF < 15%
	Moderate ARF 15-30 %
	Severe RF > 30%

Gelfand E. J Cardiovasc Mag Res 2006; 8: 503–507
Ley S. Pediatr Radiol 2007; 37:426–436

Statistical analysis

SPSS 15

Inter and intra-observer reproducibility was evaluated by means of the Intra-class Correlation Coefficient (ICC)

Inter-methods linear association was assessed by using linear regression analysis

Comparisons were considered significant in presence of a p value < 0.05

Results

Variable	Mean ± Standard deviation or absolute number (percentage)
n	32
Mean age (years)	63.0 ± 13.5
Male	22 (68.8)
Hypertension	23 (71.9)
DM	12 (37.5)
Dyslipidemia	17 (53.1)
Smoking	9 (28.1)
Atrial Fibrillation	2 (6.3)
Coronary artery disease	4 (12.5)
Previous coronary artery revascularization	3 (9.4)
Mild mitral regurgitation	18 (56.3)

Results

2D echo	Mean ±SD (n= 32)		Mean ±SD (n= 32)
LVEF (%)	62.9 ± 13.7	**SAX 2D vena contracta CSA (cm^2)**	0.5± 0,2
LAX M-mode jet width (mm)	0.6 ± 0.2	**SAX 2D LVOT CSA (cm^2)**	3.5± 0,3
LAX M-mode LVOT width (mm)	2.1 ± 0.1	**SAX 2D vena contracta CSA /LVOT CSA**	0.1± 0,06
LAX M-mode jet width / M-mode LVOT width	0.3 ± 0.1	**Regurgitant volume 2D echo-Doppler (ml)**	29.0± 3,2
LAX 2D jet width (mm)	0.5 ± 0.2	**Regurgitant fraction 2D echo-Doppler (%)**	29.8± 0,1
LAX 2D LVOT width (mm)	2.1 ± 0.1		
LAX 2D jet width / 2D LVOT width	0.2± 0.1		

Results

3D echo	Mean ±SD (n= 32)	CMR	Mean ±SD (n= 32)
3D vena contracta CSA (cm^2)	0.4 ±0,2	**Regurgitant volume CMR (ml)**	22.1±21,5
3D LVOT CSA (cm^2)	3.2±0,2	**Regurgitant fraction CMR (%)**	20.0±14,3
3D vena contracta CSA / 3D LVOT CSA	0.12±0,06	**CMR EDLVV (ml)**	204.3±78,4
3D EDLVV (ml)	180.9±72,5	**CMR ESLVV (ml)**	93.8±50,9
3D ESLVV (ml)	81.6±45,6	**CRM LVEF (%)**	55.8±12,3

14 (43,8%) Mild AR
11 (34,4%) Moderate AR
7 (21,9%) Severe AR

Results

Linear regression analysis. Dependent variable: cardiac magnetic resonance-derived regurgitant fraction.

Variable	Correlation Coefficient	R square	p
Long-axis view M-mode jet width	0.66	0.40	<0.001
Long-axis view M-mode jet width / Long-axis view M-mode LVOT width	0.69	0.48	<0.001
Long-axis 2D jet width	0.65	0.42	<0.001
Long-axis 2D jet width / Long-axis 2D LVOT width	0.66	0.43	<0.001
Short-axis 2D vena contracta CSA	0.48	0.23	<0.001
Short-axis 2D vena contracta CSA / Short-axis 2D LVOT CSA	0.42	0.17	<0.001
Regurgitant volume 2D echo-Doppler	0.45	0.20	<0.001
Regurgitant fraction 2D echo-Doppler	0.40	0.16	<0.001
3D vena contracta CSA	**0.88**	0.77	**<0.001**
3D vena contracta CSA / 3D LVOT CSA	**0.87**	0.75	**<0.001**

Results

ROC curves analysis results for detection of severe CAR

Variable	AUC	p
Long-axis view M-mode jet width	0.81	<0.001
Long-axis view M-mode jet width / Long-axis view M-mode LVOT width	0.81	<0.001
Long-axis 2D jet width	0.82	<0.001
Long-axis 2D jet width / Long-axis 2D LVOT width	0.80	<0.001
Short-axis 2D vena contracta CSA	0.86	0.003
Short-axis 2D vena contracta CSA / Short-axis 2D LVOT CSA	0.87	0.003
Regurgitant volume 2D echo-Doppler	0.73	0.009
Regurgitant fraction 2D echo-Doppler	0.76	0.01
3D vena contracta CSA	**0.97**	**<0.001**
3D vena contracta CSA / 3D LVOT CSA	**0.98**	**<0.001**

Results

ROC curves analysis results for detection of severe chronic aortic regurgitation by means of 3D color-Doppler echo assessment.

Variable	AUC	Cut-off	Sensitivity	Specificity	PPV	NPV
3D vena contracta CSA	0.97	0.50 cm^2	100%	92.59%	81.82%	100%
3D vena contracta CSA / 3D LVOT CSA	0.98	0.19	100%	77.78%	60.00%	100%

Inter-observer agreement of 3DCDE CAR vena contracta cross sectional area measurement was excellent: ICC 0.89

Intra-observer agreement: ICC 0.91.

Discussion

First study that evaluates the usefulness of 3DCDE to assess the CAR severity by measuring its functional orifice using as the gold-standard method the CMR evaluation.

The results of the present work shows that 3DCDE has an excellent correlation with CMR severity evaluation.

3DCDE echo is the most accurate echocardiography parameter for measuring CAR severity using CMR data as the gold-standard method when it is compared with other traditional non-invasive echo-Doppler methods

Measurements have excellent inter and intra-observer variability

Discussion. Clinical implications

3DCDE can improve the CAR severity assessment and consequently the management of patients suffering from this valvular heart disease.

3DCDE is becoming a useful diagnostic method and it could be able to replace other non-invasive methods.

Limitations

- The echocardiographic delineation of the cardiac structures is always dependent on the quality of the image
- Relatively low temporal resolution of the 3D studies could be considered as another limitation.
- The number of patients with severe aortic regurgitation was relatively small.

Conclusions

- 3DCDE is an accurate and highly reproducible diagnostic tool for estimating CAR severity.
- Compared with the traditional echo-Doppler methods, 3DCDE has the best agreement with the CMRI determined CAR severity.
- Thus, 3DCDE is a diagnostic method that may improve the therapeutic management of patients with CAR.