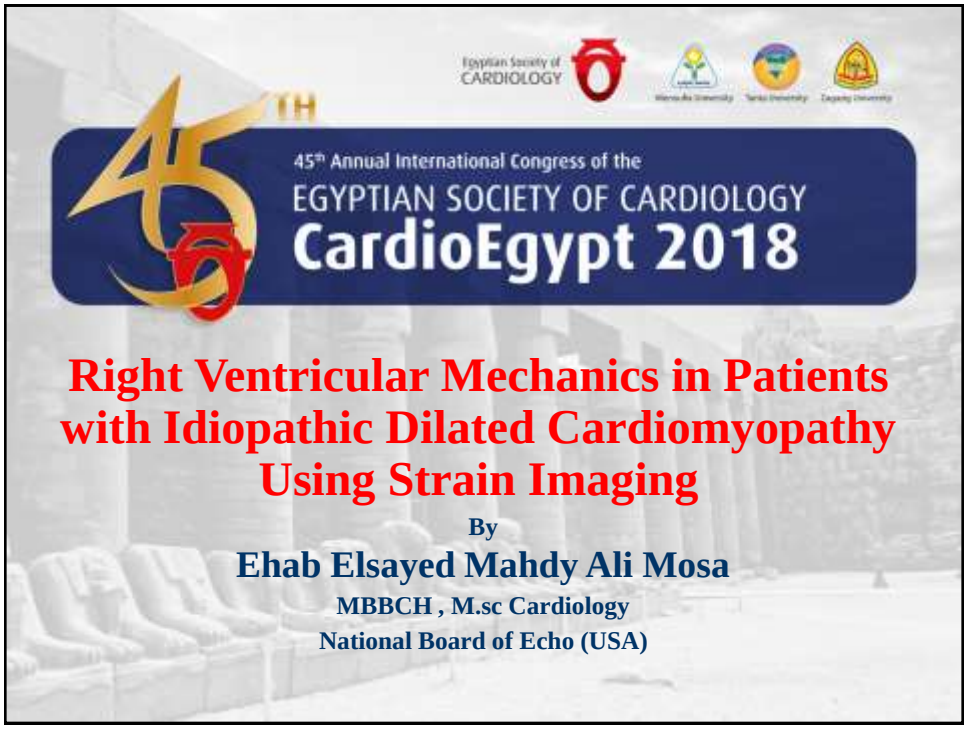

Right Ventricular Mechanics in Patients with Idiopathic Dilated Cardiomyopathy Using Strain Imaging

By

Ehab Elsayed Mahdy Ali Mosa

MBBCH , M.sc Cardiology

National Board of Echo (USA)

IDCM

Idiopathic dilated cardiomyopathy is a chronic heart muscle disease that predominantly affects young men and causes dilatation and contractile dysfunction of the left or the right ventricle, or both. The diagnosis is made by exclusion; it relies on showing the absence of coronary artery disease, valvular or pericardial disorders, and specific heart diseases.

The Right Ventricle
The Missed Side of The Heart

- For the past three decades, the left ventricular anatomy and function has been extensively researched and studied. The right ventricle (RV) has been ignored probably due to the technical difficulties in imaging as well as the poor understanding of its function and hemodynamic.

Patients with poor right ventricular function have a higher likelihood of death or transplantation than those with normal right ventricular function.

Indeed, right ventricular dysfunction is the strongest predictor of a negative outcome.

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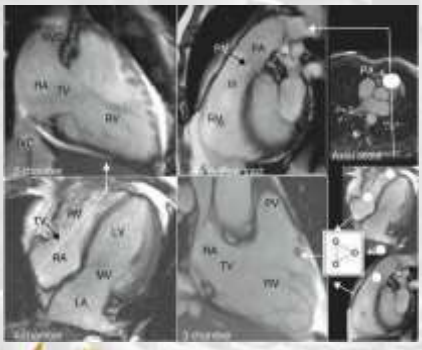
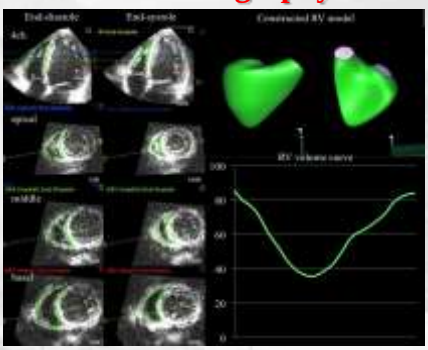
The RV can be studied with many imaging modalities

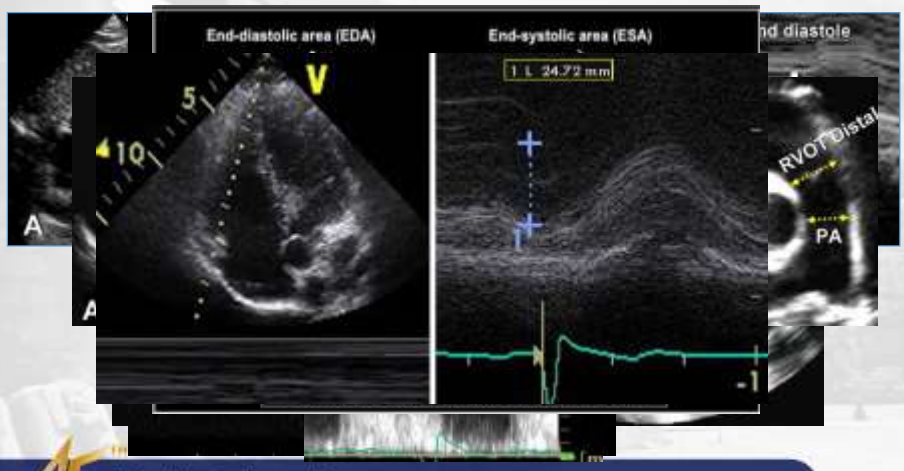
MRI **Echocardiography**



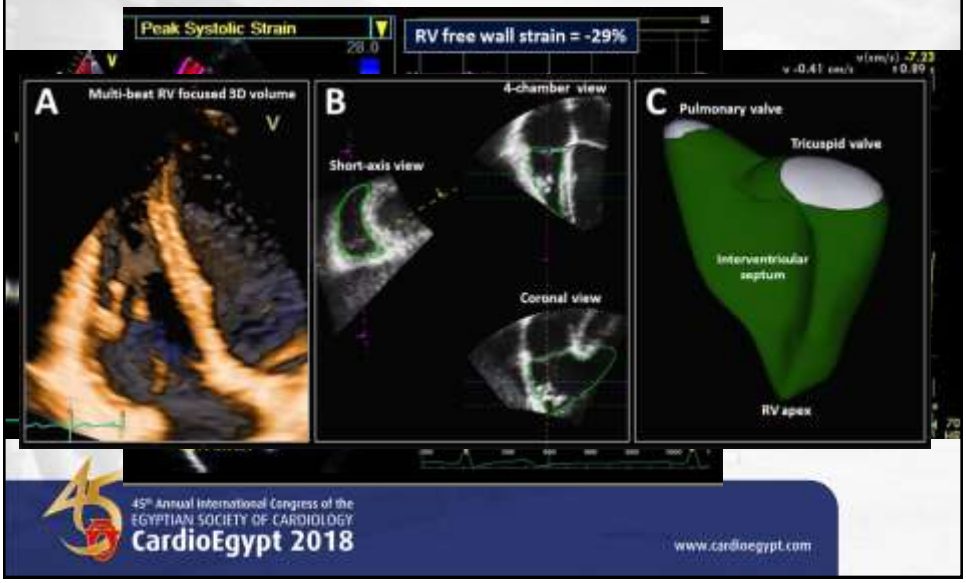


Echocardiography in the assessment of right heart function

A- Conventional Echocardiography

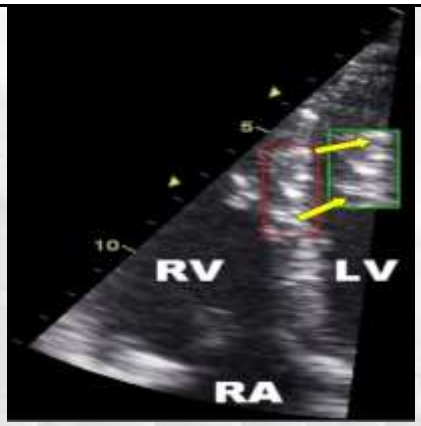


B- Advanced Echocardiographic Techniques



Speckle-tracking echocardiography

Single speckles are merged in functional units (kernels) that are in turn univocally identifiable given the peculiar disposition of the speckles. As a result, each kernel constitutes a sort of ultrasound fingerprint that can be tracked by software during the entire cardiac cycle



Typical speckled pattern of the myocardium on ultrasound in the septal wall.

The red square represents the starting location and the green square the location of the pattern at end systole.

Note the change in distance (longitudinal shortening and radial thickening of the square).

Hypothesis

We hypothesized that the same cardiomyopathic pathology may affects the right side of the heart to the same extent as the left side.

Our Mission

- To study the regional and global RV deformation using strain imaging in Idiopathic Dilated Cardiomyopathy patients

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Study Population

- **104 IDCM patients and 25 age- and sex-matched healthy subjects were enrolled in the study after their informed consent.**

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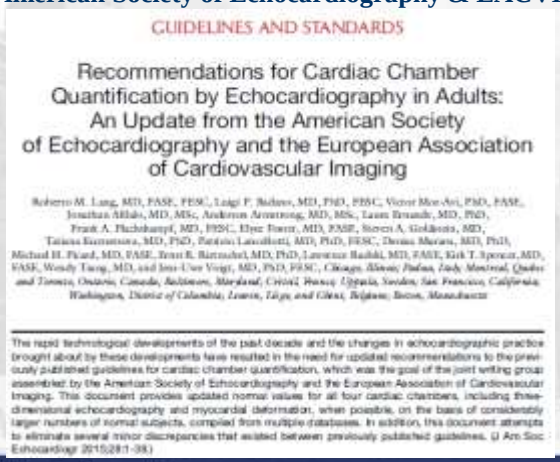
Exclusion criteria

- Systemic hypertension (> 140/100 mm Hg)
- Coronary artery disease (> 50% in one or more major branches)
- Chronic excess alcohol (> 40 g/day in women, > 80 g/day in men for more than 5 years after 6-month abstinence
- Systemic disease known to cause dilated cardiomyopathy
- Pericardial diseases
- Congenital heart disease
- Cor pulmonale
- Rapid, sustained Supraventricular tachycardia

Conventional Echocardiography:

Was done in accordance with the recommendations of the

American Society of Echocardiography & EACVI

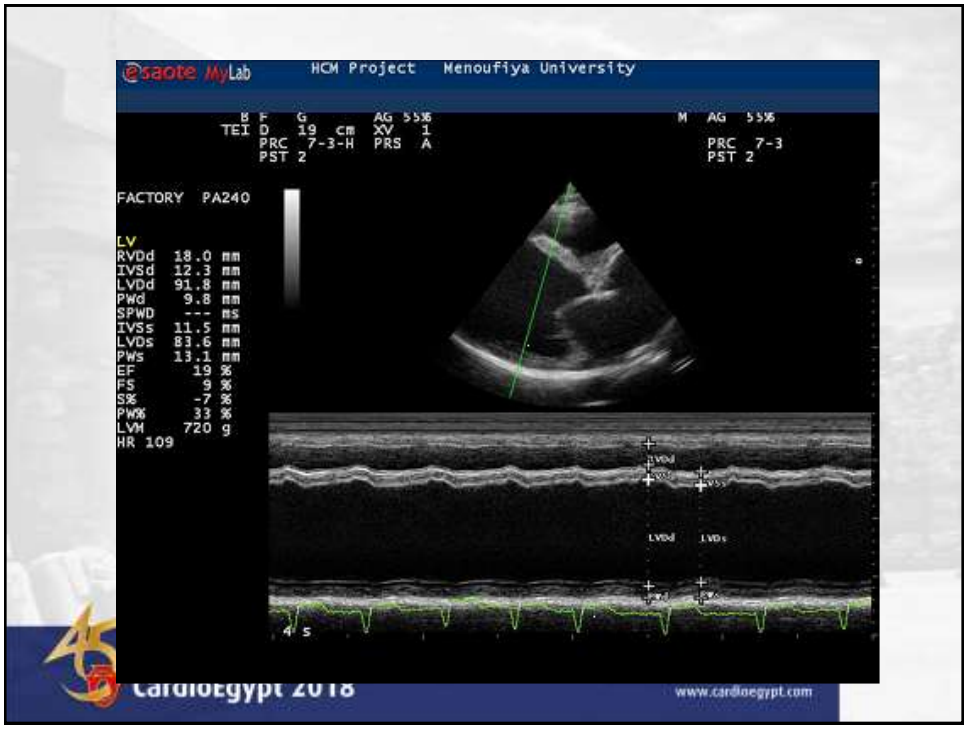


GUIDELINES AND STANDARDS

Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

Roberto M. Lang, MD, FASE, FESC, Luigi P. Badano, MD, PhD, FESC, Victor Mor-Avi, PhD, FASE, Jonathan Afilalo, MD, MSc, Anderson Armstrong, MD, MSc, Laura Ernande, MD, PhD, Frank A. Flachskampf, MD, PhD, FESC, Elyse Foster, MD, FASE, Steven A. Goldstein, MD, Tatiana Kuznetsova, MD, PhD, Patrizio Lancellotti, MD, PhD, FESC, Denisa Muraru, MD, PhD, Michal R. Picard, MD, FASE, Ernst R. Rietzschel, MD, PhD, Lawrence Rudski, MD, FASE, Kirk T. Spencer, MD, FASE, Wendy Tsang, MD, and Jens-Uwe Voigt, MD, PhD, FESC, Chicago, Illinois; Padua, Italy; Montreal, Quebec and Toronto, Ontario, Canada; Baltimore, Maryland; Ghent, Brussels; Uppsala, Sweden; San Francisco, California; Washington, District of Columbia; Leuven, Liège, and Ghent, Belgium; Boston, Massachusetts

The rapid technological developments of the past decade and the changes in echocardiographic practice brought about by these developments have resulted in the need for updated recommendations to the previously published guidelines for cardiac chamber quantification, which was the goal of the joint writing group assembled by the American Society of Echocardiography and the European Association of Cardiovascular Imaging. This document provides updated normal values for all four cardiac chambers, including three-dimensional echocardiography and myocardial deformation, when possible, on the basis of considerably larger numbers of normal subjects, compiled from multiple databases. In addition, this document attempts to eliminate several minor discrepancies that existed between previously published guidelines. (J Am Soc Echocardiogr 2015;28:1-39.)



Conventional Echo Measurements in studied groups

	DCM (N=104)	CONTROL (N=25)	P VALUE
LA diameter	**42.49±11.94**	**27.19±6.17**	0.0001
LA volume (ml)	**67.28±37.64**	**23.44±11.51**	0.0001
LA volume (ml/m2)	**37.86±17.92**	**15.50±5.45**	0.0001
ESD (mm)	**55.28±12.89**	**28.94±5.40**	0.0001
EDD (mm)	**65.76±13.16**	**45.59±8.21**	0.0001
FS%	**15.69±5.63**	**36.21±5.10**	0.0001
EF%	**31.90±9.65**	**66.56±5.49**	0.0001
Septum (mm)	**9.04±2.26**	**8.54±1.69**	NS
LVPW(mm)	**8.54±2.19**	**8.99±1.71**	NS
LVM(gm)	**319±160**	**163±87**	0.0001
LVMI(gm/m²)	**189.69±73.77**	**102.32±31.67**	0.0001
Mitral E	**85.56±33.02**	**80.73±14.95**	NS
E_{am}	8.66±3.68	17.00±3.24	0.0001
E/E_{am}	**11.11±5.20**	**4.79±0.61**	0.0001
Mitral A	41.79±30.56	51.70±20.98	NS
Mitral inflow E/A	**1.94±1.26**	**1.46±0.31**	NS
DT (ms)	142.52±53.21	170.80±31.78	.012
MR Severity			0.0001
No	**1(1%)**	**(60%)**	
Trivial	**29 (27.9%)**	**10(40%)**	
Mild	**26 (25%)**		
Moderate	**27 (26%)**		
Sever	**21(20.2%)**		
TR Severity			0.0001
No	8(7.7%)	19(76%)	
Trivial	41(39.4%)	6(24%)	
Mild	31(29.8%)	-	
Moderate	15(14.4%)	-	
Sever	9(8.6%)	-	
PAP (mmHg)	**33.2±12.10**	**18.40±2.80**	0.0001

RV Dysfunction was recognized by systolic velocity of lateral tricuspid annulus (Sm) <9.5cm/s

Normal values for parameters of RV function

Parameter	Mean ± SD	Abnormality threshold
TAPSE (mm)	24 ± 3.5	<17
Pulsed Doppler S wave (cm/sec)	14.1 ± 2.3	<9.5
Color Doppler S wave (cm/sec)	9.7 ± 1.85	<6.0
RV fractional area change (%)	49 ± 7	<35
RV free wall 2D strain* (%)	−29 ± 4.5	>−20 (<20 in magnitude with the negative sign)
RV 3D EF (%)	58 ± 6.5	<45
Pulsed Doppler MPI	0.26 ± 0.086	>0.43
Tissue Doppler MPI	0.38 ± 0.08	>0.54
E wave deceleration time (msec)	180 ± 31	<119 or >242
E/A	1.4 ± 0.3	<0.8 or >2.0
e'/a'	1.18 ± 0.33	<0.52
e'	14.0 ± 3.1	<7.8
E/e'	4.0 ± 1.0	>6.0

MPI, Myocardial performance index.
*Limited data; values may vary depending on vendor and software version.

Left Ventricular Deformation

- **Speckle tracking was done to LV and subsequent strain calculations were performed εsys, SRsys, SR e and SRa to all 16 segments.**
- **By averaging all previously collected data LV Global ε sys, SR sys, SRe dia and SRa dia were obtained.**
- **LV dyssynchrony was defined as the standard deviation of the averaged time-to-peak-strain (TTP-SD).**

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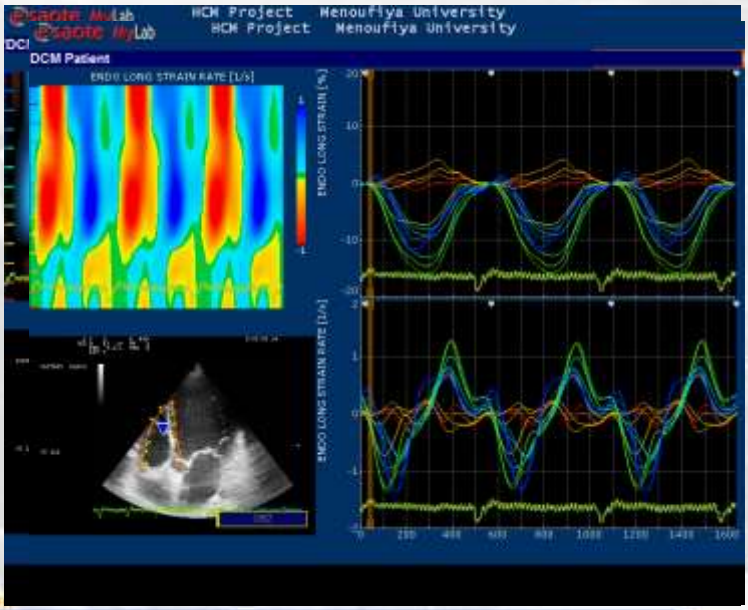
Left Ventricular Deformation in studied groups

	IDCM (N=104)	CONTROL (N=25)	P VALUE
Global LV ε_{sys}%	-5.81±4.16	-19.88±2.49	**0.0001**
LV TTP-SD (ms)	84.79±61.61	29.24±16.81	**0.0001**
Global LV SR $_{sys}$ (s^{-1})	-0.50 ±0.49	-1.29±0.21	**0.0001**
Global LV SR$_e$ (s^{-1})	0.40±0.290	1.56±0.31	**0.0001**
Global LV SR$_a$ (s^{-1})	0.33±0.300	0.60±0.100	**0.0001**

Right Ventricular Deformation



- **Longitudinal εsys, systolic SR (SRsys), early diastolic (SRe), atrial diastolic (SRa) in the basal, mid and apical segments of RVFW and interventricular septum.**

- **Global RV deformation was calculated by averaging all previously collected data from RVFW and septal segments.**

- **RV electromechanical delay was measured as the difference between TTP (d-TTP) in 6 RV segments , RV dyssynchrony was defined as the standard deviation of the averaged time-to-peak-strain (TTP-SD).**

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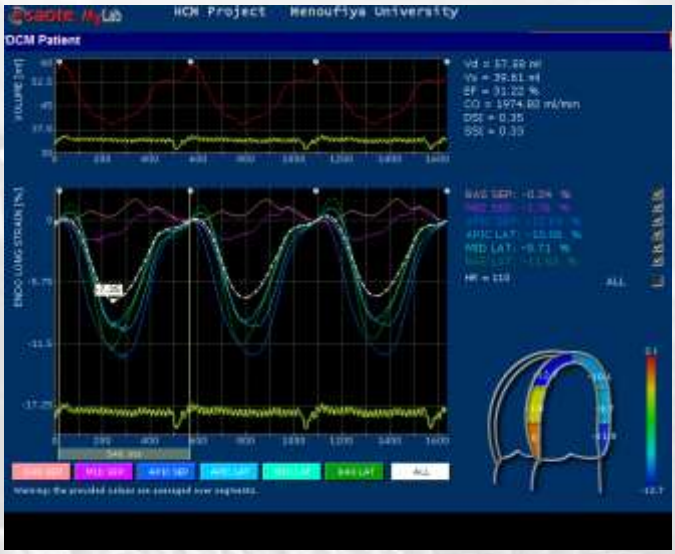


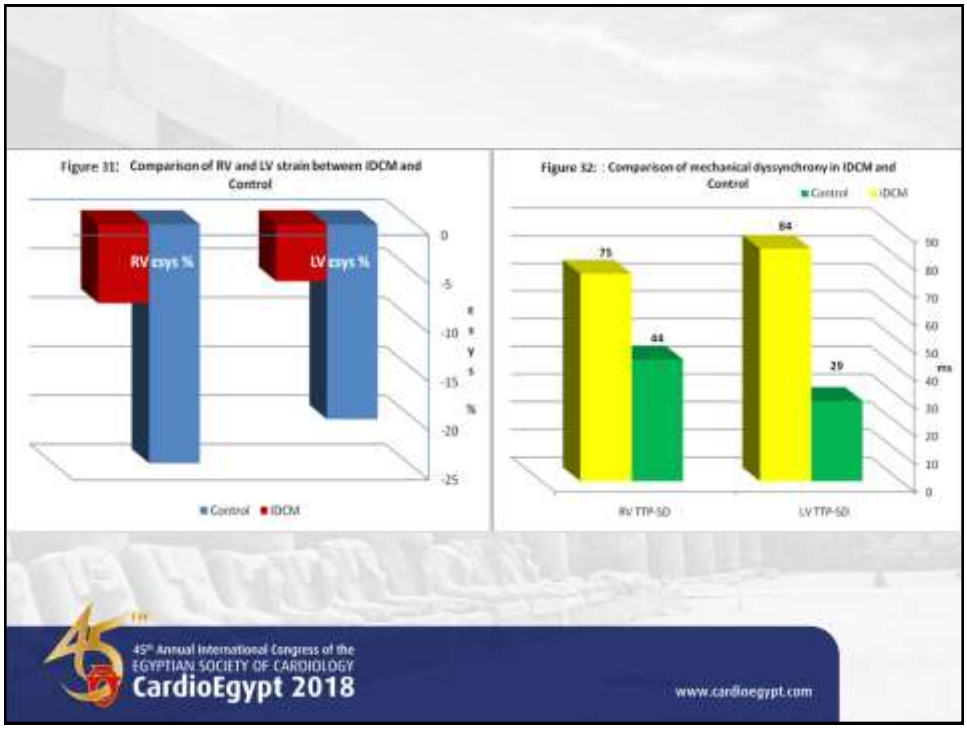
VVI strain of RVFW and septal segments in apical 4 CH view in patients with IDCM, The mean value of longitudinal **εsys = -7.35%.**

VVI strain of RVFW and septal segments in apical 4 CH view in patients with IDCM, **The electromechanical delay between segments is 304 msec.**

RV deformation analysis including RVFW and septal segments in apical 4C view, demonstrating strain rate curves of all segments. **The mean SRsys is-0.65s^{-1} ,SRe dia is 0.55 s^{-1}.**

Right Ventricular Regional and Global Deformation

	DCM (N=104)	CONTROL (N=25)	P VALUE
εsys % Basal RVFW	-14.41±11.27	-31.25±4.16	**0.0001**
εsys % Mid RVFW	-8.29±6.73	-28.44±3.43	**0.0001**
εsys % Apical RVFW	-6.82±6.33	-32.89±5.72	**0.0001**
εsys % Mean RVFW	**-9.84±6.73**	**-30.86±4.44**	**0.0001**
εsys % Basal Septum	-9.16±7.21	-12.69±6.13	**0.025**
εsys % Mid septum	-7.79±6.22	-23.80±8.52	**0.0001**
εsys% Apical septum	-7.18±5.32	-17.68±5.06	**0.0001**
εsys % Mean septum	**-8.05±5.78**	**-17.37±3.59**	**0.0001**
εsys % Global RV	**-8.94±5.51**	**-24.11±4.02**	**0.0001**
RV TTP Min(ms)	248.46±114.54	300.72±58.71	**0.029**
RV TTP Max(ms)	432.87±138.28	409.76±65.56	**NS**
RV TTP-d (ms)	184.40±116.02	109.04±61.29	**0.002**
RV TTP-SD (ms)	**75.7±47.8**	**44.18±26.7**	**0.002**
SR_{sys} (s^{-1})Basal RVFW	-1.31±0.86	-2.78±1.09	**0.0001**
SR_{sys}(s^{-1}) Mid RVFW	-0.72±0.42	-1.74±1.04	**0.0001**
SR_{sys} (s^{-1})Apical RVFW	-0.62±0.36	-0.73±0.40	**NS**
SR_{sys}(s^{-1}) Mean RVFW	**-0.88±0.47**	**-1.75±0.68**	**0.0001**
SR_{sys} (s^{-1})Basal Septum	-0.94±0.64	-1.23±0.26	**0.025**
SR_{sys} (s^{-1})Mid septum	-0.74±0.51	-1.13±0.26	**0.0001**
SR_{sys} (s^{-1})Apical septum	-0.62±0.35	-0.91±0.22	**0.0001**
SR_{sys} (s^{-1}) Mean Septum	**-0.77±0.46**	**-1.09±0.22**	**0.001**
SR_e (s^{-1}) mean RVFW	**0.67±0.50**	**2.08±1.08**	**0.0001**
SR_e (s^{-1}) Mean Septum	**0.56±0.50**	**1.22±0.33**	**0.0001**
SR_e (s^{-1}) Global RV	**0.62±0.42**	**1.65±0.63**	**0.0001**



Comparison between DCM patients with and without RV dysfunction

	without RV dysfunction (n=58)	With RV dysfunction (n=46)	P* VALUE
LA volume (ml/m2)	34.03±16.65	42.73±18.48	0.015
ESD	52.61±12.97	58.63±12.13	0.017
EF%	34.60±9.68	28.50±8.55	0.001
LVMI	174.91±65.23	208.49±80.26	0.023
LV Global εsys%	-6.87±4.51	-4.48±3.25	0.003
LV Global SR_e	0.45±0.32	0.33±0.24	0.040
LV Global SR_a	0.39±0.36	0.24±0.14	0.008
RV Long Diameter	60.97±13.19	66.37±11.37	0.030
RV Mean Diameter	41.28±8.58	44.94±6.72	0.019
RV wall thickness	6.17±1.58	6.97±1.31	0.007
εsys % GlobalRV	-10.36±6.05	-7.15±4.17	0.003
SR sys RV Global	-0.93±0.44	-0.69±0.33	0.002
SRedia GlobalRV	0.73±0.48	0.48±0.27	0.002
SR adia RVGlobal	0.70±0.39	0.41±0.21	0.0001
Em lat anulus	12.40±4.01	8.29±6.51	0.0001
Am lat anulus	13.84±5.38	7.64±6.21	0.0001
Mean Displac	3.92±2.35	2.74±2.05	0.009
RV EF	29.92±12.89	24.38±12.97	0.032

To explore the cutoff point that discriminate RV dysfunction we constructed ROC curves for RV εsys, SRsys, SRe and SRa in IDCM

	Cutoff value	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound	Sensitivity	Specificity
RV ε_{sys} (%)	-8.7	0.653	0.053	0.008	0.548	0.757	63%	60.3%
RV SR_{sys} s^{-1}	-0.76	0.683	0.053	0.001	0.580	0.787	71.7%	60.3%
RV SR_e s^{-1}	0.53	0.659	0.053	0.006	0.555	0.764	62.2%	60.3%
RV SR_a s^{-1}	0.58	0.731	0.049	0.000	0.635	0.827	73.3%	60.3%

Independent predictors of RV dysfunction in IDCM

		B	S.E.	Wald	Sig.	Exp(B)
Step 1[a]	Age (yrs)	**-0.075**	**0.036**	**4.221**	**0.040**	**0.928**
	BSA	0.475	1.461	0.106	0.745	1.608
	mitral E/A	0.153	0.382	0.160	0.689	1.165
	LV TTP-SD	**-0.015**	**0.006**	**6.430**	**0.011**	**0.985**
	Mean RV FW εsys %	-0.032	0.084	0.141	0.708	0.969
	Global RV SR_{sys}	0.325	1.729	0.035	0.851	1.384
	Global RV SR_e	**-3.092**	**1.237**	**6.249**	**0.012**	**0.045**
	RV Global SR_a	-1.730	1.392	1.544	0.214	0.177
	Constant	8.027	3.021	7.062	0.008	3062.938

We identified the following major findings:

- **First, impaired RV-longitudinal mechanics is a prominent feature when compared to healthy individuals.**
- **Second, both RV free wall and global RV deformations are interrelated.**
- **Third, Quantitative RV functional evaluation revealed that the reduction in RV systolic and diastolic function was strongly correlated with LV structure and function in IDCM.**

- **Interestingly, the present study sights the existence of extreme right ventricular myocardial systolic non-uniformity and dyssynchrony in DCM as evidenced by increased values of RV TTP-SD, even in absence of intraventricular conduction delay. RV deformation was strongly related to intra-V asynchrony which is the most powerful predictors of sudden cardiac death .**

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Conclusion

Deterioration of RV mechanics in IDCM is a prominent feature, it is closely related to LV phenotype, application of speckle tracking in IDCM offers incremental information in this cardiomyopathy beyond clinical and conventional echocardiographic parameters.

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European Heart Journal
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Characterization of Right ventricular deformation in idiopathic dilated cardiomopathy using Vector Velocity Imaging
Objective: We attempted to investigate the right ventricular (RV) long axis function using speckle tracking, and its relation to left ventricular (LV) phenotype in patients with idiopathic dilated cardiomyopathy (IDCM).
Methods: In 102 patients with IDCM mean age 37±13years, RV and LV strain (ε%), strain rate during systole (dSRs) and diastole (dSRe and dSRa) was analyzed, Electromechanical delay between RV and LV myocardial wall segments were measured and its corresponding dyssynchrony (TTP–SD) was estimated. Tissue Doppler velocities from tricuspid annulus of RV free wall (RVFW) were measured Ea, Aa, Sa.
Results: Assessment of RV strain offered incremental information compared to clinical context. Even in the subgroup with RV dysfunction (tricuspid annular velocity <9.5 cm/sec) (n=43 (42%)) both regional and global RV strain parameters were significantly reduced. RV deformation parameters were directly correlated to LV dimension, LA volume index, LV mass index, pulmonary artery pressure (PAP) and LV stiffness. Additionally, Multivariate logistic regression analysis showed that age, LV dysmyofunction and RV ε% are independent predictors of RV dysfunction (P< .001).
Conclusion: Deterioration of RV mechanics in IDCM is a prominent feature. It is closely related to LV phenotype. Application of speckle tracking in IDCM offers incremental information in this complex cardiomyopathy beyond clinical and conventional echocardiographic parameters.
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