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Original Article

Assessment of Right Ventricular Functions in Patients with Ischemic Heart Disease before and after Percutaneous Coronary Intervention using Colored Tissue Doppler Imaging

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ABSTRACT

Background: Right Ventricular (RV) dysfunction considered as a predictor of mortality in patients with ischemic heart disease (IHD). **Aim:** This study was aimed to evaluate the impact of elective coronary artery revascularization on RV myocardial function in Egyptian patients with IHD using Colour Tissue Doppler Imaging (CTDI). **Methods:** The present study is prospective observational self-control study. Fifty consecutive patients with IHD were included in this study. All participants were subjected to physical examination, Electrocardiograph (ECG), Laboratory test, Transthoracic Echocardiography and color tissue Doppler Imaging. The RV myocardial performance index (MPI) and S'/RMPI index were calculated in TDI modalities parameters. **Results:** No significant differences were detected between the demographic characteristics of the investigated patients. Tricuspid annular plane systolic excursion (TAPSE) by echocardiographic RV function parameters was improved significantly after PCI (P=0.001). Most of RV myocardial function showed significant improvement after PCI by using PW-DTI: Early and late diastolic function: The E` and A` diastolic wave velocities were improved significantly after PCI (P= 0.003, P= 0.008 respectively), RMPI (P= 0.008) S`/RIMP ratio (P=0.04). The myocardial functions showed significant improvement after PCI by using color-coded tissue Doppler; E` wave (P= 0.02), RMPI was improved significantly after PCI (P= 0.01). **Conclusion:** The TAPSE and Doppler tissue indices added important information to the RV functions after successful percutaneous revisualization of coronary arteries. The measurements performed by color-coded TDI derived myocardial velocities at basal, mid and apical might have added additional data describing RV function and its recovery after RV ischemia.

Key words: Coronary Artery Disease, Percutaneous Coronary Intervention, Echocardiography, Tissue Doppler imaging, Right Ventricular Function.

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INTRODUCTION

The right ventricle (RV) has an essential function in cardiovascular physiology and pathology. The RV plays an important role in the morbidity and mortality of patients with cardiopulmonary diseases.[1] Assessment of RV by echocardiography has practical applications particularly in patients with acute cardiac conditions, such as pulmonary emboli, acute heart failure, cardiogenic shock, cardiac tamponade and acute valvular dysfunction.[2] The RV dysfunction has been introduced as a good predictor for mortality in AMI patients.[3,4]

The RV has a more complex geometrical form than LV.[5] The RV contraction is mainly determined by longitudinal shortening due to the structural organization of the RV myocardial fibers.[6]

Assessment of the RV for clinical purposes and response to therapeutics has been challenging. Accurate and relatively load independent evaluation of RV hemodynamics can be accurately performed by invasive measurements, primarily by the use of conductance catheters that allow simultaneous volume and pressure measurements under manipulation of loading and contractility.[7] Non-invasively and thus more appropriate for most clinical purposes Magnetic Resonance Imaging (MRI) can estimate RV volume with satisfactory accuracy.[8]

Echocardiography is the modality of choice for the assessment of morphology and function of the RV in clinical practice as it is non-invasive, widely available, relatively inexpensive and having no side effects. Echocardiography has been challenged by the retrosternal position of the RV limiting the echocardiographic window and the complex shape of the RV that makes calculation of volumes based on geometrical assumptions of shape impossible.[9]

Furthermore the load dependence of the thin-walled RV with its low afterload physiology will influence measures of RV function based on volumes alone.[10]

In order to proceed via the "right way" to examine the RV, the echocardio-graphers should first conduct the echocardiographic examination with regard to the clinical context. A comprehensive examination of the RV may be time consuming and a case- by-case decision is made by experienced echocardiographers in order to yield an appropriate assessment.[1]

The challenges of RV function assessment encountered with conventional echocardiography may be overcome with the use of newer echocardiographic techniques such as 3DE and STE.[11]

Various echocardiographic techniques as the time- motion mode (M-Mode), two-dimensional echo (2DE), Pulsed Wave Doppler (PWD), Doppler tissue imaging (DTI), STE and 3DE, provide valuable qualitative and quantitative data regarding RVD and RVF when used in conjunction with tricuspid flow and pulmonary artery hemodynamics, such data allow a better understanding of the structure, function and pathophysiology of the right heart.[1]

Tissue Doppler echocardiography has been proved to sensitively detect systolic and diastolic dysfunction.[12,13] Tissue Doppler velocity imaging represents an accurate, reliable, feasible and relatively quick and simple method. An advantage of using TDI to assess RV function is that measurement is independent of geometric assumptions and endocardial border tracing.[14] Unlike conventional visual assessment of regional wall motion abnormalities, requiring subjective interpretation, tissue Doppler velocities can be quantified objectively. The potential of tissue Doppler–

derived measures in identifying ischemia has been established in different experimental and clinical settings.[15]

Tissue Doppler imaging is obtained using pulsed wave tissue Doppler or colour tissue Doppler imaging (CTDI). Pulsed wave TDI measures peak longitudinal myocardial velocity from a single segment, but has to be performed 'on line'. Colour tissue Doppler imaging is performed 'off line' and can interrogate velocities from multiple sites simultaneously.[16]

The development of technology for measurement of regional myocardial velocities by means of tissue Doppler and software for calculation of regional deformation and deformation rate in the LV have offered researchers a promising new technology for non- invasive assessment of RV myocardial function.[17] Shortly thereafter studies reported on the applicability of tissue Doppler based deformation analysis in the RV as well.[18,19]

These new parameters seemed clinically useful and potentially less load dependent than other echocardiographic markers of RV myocardial performance.[9] Three dimensions (3D) echocardiography has provided promising results, but is time- consuming and has limited feasibility.[20]

The aim of this study was to determine the impact of elective coronary artery revascularization on RV myocardial function assessed by echocardiography in IHD.

MATERIALS AND METHODS

The present study is prospective observational self-control study. The study was carried out on fifty consecutive patients with Ischemic Heart Disease (IHD), who were candidate for elective Percutaneous Coronary Intervention (PCI). Patients were investigated before the intervention to evaluate baseline systolic and diastolic function.

The inclusion criteria of the study were presence of persistent sinus rhythm, significant coronary artery stenosis that was defined in the coronary angiogram by the presence of occlusion or >70% stenosis with successful PCI of the left anterior descending (LAD), left circumflex (LCx) and right coronary artery (RCA).

Patients having any of the following diseases were excluded from this study:

a) Atrial fibrillation, Left bundle branch block,
b) Paced rhythm, Significant valvular heart disease,
c) History of obstructive pulmonary disease or any other chronic respiratory conditions with pulmonary hypertension with RV systolic pressure by Echo >40 mmHg,
d) History of Pulmonary embolism, History of coronary artery bypass grafting (CABG) or valvular surgery,
e) History of cardiomyopathy,
f) Patients with non-cardiac diseases that carry increased risk of mortality including renal or hepatic failure, or cancer not in complete remission
g) Patients with poor Echo window.

The full history was taken from each participant including age, gender, occupation, chest pain and risk factors as hypertension, Diabetes Miletus (DM), dyslipidemia, cigarette smoking and history of Ischemic Heart Disease (IHD), previous admission to CCU and detailed history of previous medication. Hypertension was defined by persistent resting systolic blood pressure > 140 mm Hg, diastolic blood pressure > 90 mm Hg or current treatment with blood pressure-lowering medications. Diabetes was defined by prior diagnosis with current antidiabetic medications. Dyslipidemia was defined by prior diagnosis with current cholesterol-lowering medications, or fasting serum cholesterol, low density lipoprotein (LDL) and high density lipoprotein (HDL) cholesterol, triglycerides levels were >200 mg/dl, > 100mg/dl and <35 mg/dl, >150 mg/dl, respectively. Smokers were defined as current smokers.

The patients were examined clinically with emphasis on pulse, blood pressure and complete cardiac and chest examination. Venous blood samples were collected from each patient up- on their admission for biochemical assessment of Blood glucose, serum creatinine and troponin I values. Resting standard 12 leads surface ECG was done for all patients. The participants were initially evaluated by transthoracic echocardiography and tissue doppler imaging prior to PCI which was performed with the ECG gating and patients were ordered to lying in the left decubitus position using General Electric Vivid E9 (GE Healthcare, USA) and the M5Sc transducer. The baseline of the systolic and diastolic RV function parameters were assessed. The left ventricular systolic function also was evaluated. The reference limits of all the echocardiographic parameters were defined according to the American Society of Echocardiography (ASE) Guidelines. The Echocardiography was repeated one month after intervention and the results were compared with baseline.

Tricuspid annular plane systolic excursion (TAPSE)

TAPSE was obtained in the A4C view using M-mode that was placed through tricuspid annulus at lateral RV free wall. TAPSE was measured as the total displacement of the tricuspid annulus (millimeters) from end-diastole to end-systole, with values representing TAPSE.

Pulsed wave Tissue Doppler imaging (TDI)

Pulsed TDI images were acquired by placing TDI cursor on the RV free wall at the level of tricuspid annulus. 3.5 mm sample volume was used. Gains were optimized and low wall filter settings were selected (50 Hz). Doppler velocity range of - 20 to + 20 cm/s and sweep speed of 50 mm/s were selected. Myocardial tissue Doppler velocities were measured (in centimeters per second). All measurements of the TDI obtained were performed offline.

The TDI was used for measuring RV S` velocity (A major positive velocity (S`) was recorded during systole, read as the highest systolic velocity, without over gaining the Doppler envelope. During diastole, as the two major negative waves were recorded-one during early diastole (E`) and one during late diastole (A`), early diastolic RV A` velocities and the late diastolic RV E` velocities were also measured.

The TDI obtained above was also used for measuring RV MPI; as TCO is the time from tricuspid valve closure to tricuspid valve opening that includes iso-volumic contraction time (ICT), ET and iso-volumic relaxation time (IRT). It was measured as the time interval between the end of atrial systolic contraction (A`) of the preceding cardiac cycle and the beginning of early diastolic tricuspid valve annular velocity (E`) wave of the subsequent cardiac cycle where S` duration was measured as ejection time (ET) (Figure 1). Right ventricular MPI as (TCO - ET) / ET. S`/RIMP ratio was calculated.

Color-coded Tissue Doppler Imaging (TDI)

Color Doppler coded images were recorded from the apical 4-chamber view; the ventricular wall motion velocities were assessed during the cardiac cycle. Velocities toward the transducer are color-coded red and velocities away from the transducer are color-coded blue.

A cine-loop of 3 consecutive loops is stored for off-line analysis. Off-line measurements for regional myocardial velocity are performed in the three basal, mid and apical RV free wall segments. Also, measurement of the IVCT, ET and IVRT with calculation of the RMPI and S`/RIMP ratio.

All the echocardiography studies were repeated one month after the procedure and the results were compared to baseline. All the echocardiographic evaluations were performed by a two cardiologist who are blind to the coronary anatomy and target vessel for intervention. To decrease intra-observer variability echocardiographic values were presented as the average of three measurements.

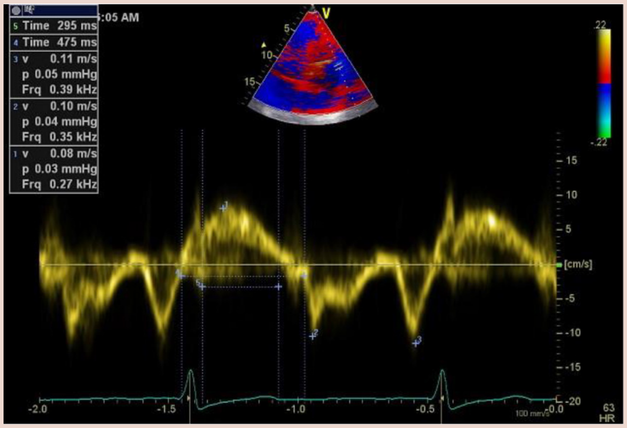

Figure 1: Iso-volumic contraction time (ICT), Ejection time (ET) and iso-volumic relaxation time (IRT), early diastole (E`) and late diastole (A`). Right ventricular MPI is calculated as (TCO - ET) / ET.

Coronary angiography

Coronary angiography and Percutaneous Coronary Intervention (PCI) was performed for all patients in a single session at our center using Siemens Angiocore Machine (Siemens, Germany) via femoral artery approach by experienced interventional cardiologists, Ultravist 300 (Iopromide, Bayer Pharma, Germany) was used as contrast agent.

Aspirin 150 mg once daily, clopidogrel 300 mg oral loading dose day before PCI, then 75 mg per day and I.V. 10000 unit unfractionated heparin during PCI in addition to conventional treatment.

Coronary angiography finding in the study population were, affection of The LAD in 35 (70%) patients, RCA in 24 (48%) patients, LCX in 12 (24%) patients and no one had left main artery (LM). Of 50 study patients; 28 (56%) of them had single vessel disease and 22 (44%) had multi-vessel disease. Successful PCI were done for all significant stenotic lesions using bare metal stents (BMS) and drug eluting stents (DES).

The performed intervention, as well as the choice whether or not to use coronary stents, was at the treating cardiologists' decision.

A successful revascularization procedure was considered when a TIMI epicardial flow grade III was restored. There were no procedural complications and no re-interventions required during the 1 month follow up period.

Statistical analysis

Data were collected, tabulated and finally analyzed statistically using SPSS version 16 statistical program. Descriptive data were presented as mean ± standard deviation (Mean ± SD) for all quantitative values, or number of cases (percentage) for categorical variables. Normal distribution of continuous parameters was tested by Kolmogorov-Smirnov test. Comparisons between groups for categorical variables were performed using the χ^2 (chi-square) test or Fisher's exact test, which appropriate. The significance of differences between continuous variables was determined with independent samples *t*- test for parameters with normal distribution. Comparisons between groups before and after PCI were performed using paired-Samples *t* test.

The significance of correlations was determined using Pearson's correlation coefficient. Statistical significance was determined as P values < 0.05.

All the statistical analyses were performed using the SPSS statistical software, version 16 (SPSS Inc., Chicago, Illinois, USA).

Ethical statement

Written informed consents were obtained from all the study patients before recruitment and the study proposal was approved by the Research Board and Ethics Committee of Mansoura University of Medical Sciences.

RESULTS

The characteristics of patients were summarized in Table 1. Out of 50 patients (34 (68%) male and 16 (32%) female) with acute coronary syndrome, 28 (66%) patients with myocardial infarction, 22 (34%) patients with unstable angina. The mean age of the study population was 52.92±9.97 years. Overall 16 (32%) patients were diabetic, 23 (40%) patients were hypertensive, 5 (10%) were smoker and 15 (30 %) patients were suffering from dyslipidemia. All patients were medicated on aspirin, 12 (24%) patients on beta-blockers, 23 (46%) on angiotensin-converting enzyme inhibitors and 12 (24%) of them on statin therapy.

The coronary angiographic data was illustrated in Table 1. The most frequent affected blood vessel was LAD in 35 patients (49%) followed by right coronary artery (RCA) in 24 (34%) patients, left circumflex (LCx) in 12 (17%) patients and no one had left main (LM). Twenty-eight patients (56%) suffered from single vessel disease and 22 (44%) patients suffered from multi vessel disease.

The right ventricular (RV) myocardial function before and After PCI are showed in Table 2. TAPSE was improved significantly after PCI (P= 0.001). Most of myocardial function showed significant improvement after PCI by using TDI where E` and A` diastolic wave velocities were P= 0.003 and P= 0.008, respectively, RMPI (P= 0.008) and S`/RIMP ratio (P=0.04). Some of myocardial function showed significant improvement after PCI by using color-coded tissue Doppler where E` (P= 0.02), RMPI (P= 0.01) and S`/RIMP ratio (P=0.07).

Table 1: Baseline characteristics and coronary angiographic data among the studied patients.

Criteria		Frequencies	
	No.	%	
Age (mean± SD) years		52.92±9.97	
Gender	Male	34	68
	Female	16	32
Hypertension		23	46
Diabetes		16	32
Myocardial infarction		28	66
Unstable angina		22	44
Smoking		5	10
Dyslipidemia		15	30
Medications	B-blocker	12	24
	ACEI	23	46
	Statin	12	24
	Aspirin	50	100
left anterior descending (LAD) coronary artery		35	49
right coronary artery (RCA)		24	34
left circumflex (LCx)		12	17
Left main (LM)		0	0
single vessel disease		28	56
multi vessel disease		22	44

Table 2: PW-DTI and Color-coded tissue Doppler parameters among the studied cases before and after PCI.

Criteria* Mean ± SD		Before PCI** Mean ± SD	After PCI	P- Value
TAPSE (mm)		22.3 ± 0-27	23.9± 0.42	0.001
PW-DTI	S` WAVE (cm/sec)	12.9 ± 2.7	13.2 ± 2.8	0.5
	E` WAVE (cm/sec)	9.4 ± 2.8	11.2 ± 2.9	0.002
	A` WAVE (cm/sec)	17.8 ± 6.1	15.4 ± 7.4	0.003
RMPI		0.94 ± 0.35	0.76 ± 0.2	0.008
S` /RMPI		14.1 ± 7.4	18.2 ± 10.3	0.04
Color-coded Tissue Doppler				
S` WAVE (cm/sec)	Base	9.68 ± 2.18	10.21 ± 2.23	0.1
	Mid Cavity	6.91 ± 2.41	6.97 ± 1.94	0.82
	Apex	3.6 ± 1.78	3.58 ± 1.88	0.6
E` WAVE (cm/sec)	Base	-7.03 ± 2.14	-8.02 ± 2.37	0.2
A` WAVE (cm/sec)	Base	-10.24 ± 3.48	-10.39 ± 3.95	0.8
RMPI		0.79 ± 0.3	0.66 ± 0.28	0.01
S` /RMPI		14.56 ± 8.0	17.00 ± 7.78	0.07

* TAPSE: Tricuspid Annular Plane Systolic Excursion; PW-DTI: Pulsed Wave-Doppler Tissue Imaging; RMPI: right ventricular myocardial performance index; S`: Peak systolic; E`: peak early diastolic velocities; A`: late diastolic velocities of lateral tricuspid annulus

** PCI: Percutaneous Coronary Intervention

Table 3: RV myocardial parameters by TDI and colored coded tissue Doppler among the study cases with RCA before and after PCI. Comparisons between groups were performed using the paired samples *t*-test.

Criteria* Mean ± SD		Before PCI** Mean ± SD	After PCI	P- Value
TAPSE (mm)		22.6 ± 2.5	23.3± 5.2	0.27
PW-DTI	S` WAVE (cm/sec)	12.7 ± 2.8	11.9 ± 1.7	0.8
	E` WAVE (cm/sec)	10.1 ± 3.8	11 ± 2.8	0.3
	A` WAVE (cm/sec)	13.6 ± 3.9	16.8 ± 2.7	< 0.001
RMPI		0.94 ± 0.3	0.67 ± 0.14	< 0.001
S` /RMPI		14.9 ± 8.5	18.1 ± 3.9	0.11
Color-coded Tissue Doppler				
S` WAVE (cm/sec)	Base	8.84 ± 2.35	10.88 ± 2.5	< 0.001
	Mid Cavity	6.65 ± 2.33	7.74 ± 1.9	< 0.001
	Apex	3.54 ± 1.92	4.1 ± 1.9	0.14
E` WAVE (cm/sec)	Base	-7.16 ± 2.86	-8.79 ± 1.81	0.01
A` WAVE (cm/sec)	Base	-9.26 ± 4.1	-9.2 ± 4.51	0.9
RMPI		0.84 ± 0.35	0.7 ± 0.27	0.12
S` /RMPI index		14.3 ± 9.35	17.02 ± 5.9	0.056

* TAPSE: Tricuspid Annular Plane Systolic Excursion; PW-DTI: Pulsed Wave-Doppler Tissue Imaging; RMPI: right ventricular myocardial performance index; S`: Peak systolic; E`: peak early diastolic velocities; A`: late diastolic velocities of lateral tricuspid annulus

** PCI: Percutaneous Coronary Intervention

Table 4: RV myocardial parameters by TDI and colored coded tissue Doppler among the study cases with LAD before and after PCI. Comparisons between groups were performed using the paired samples *t*-test.

Criteria* Mean ± SD		Before PCI** Mean ± SD	After PCI	P- Value
TAPSE (mm)		22.2 ± 2.8	23.7± 4.5	0.02
PW-DTI	S` WAVE (cm/sec)	12.7 ± 2.9	13.6 ± 2.8	0.19
	E` WAVE (cm/sec)	8.7 ± 3	10.9 ± 2.8	0.02
	A` WAVE (cm/sec)	18.1 ± 6.8	15.9 ± 4.7	0.14
RMPI		0.98 ± 0.37	0.78 ± 0.2	0.02
S` /RMPI		12.8 ± 4.1	17.1 ± 4.9	0.002
Color-coded Tissue Doppler				
S` WAVE (cm/sec)	Base	9.6 ± 2.34	9.69 ± 2.21	0.85
	Mid Cavity	6.7 ± 2.5	6.04 ± 1.84	0.096
	Apex	3.52 ± 1.76	2.71 ± 1.87	0.01
E` WAVE (cm/sec)	Base	-6.81 ± 2.23	-7.81 ± 2.1	0.056
A` WAVE (cm/sec)	Base	-9.78 ± 3.6	-10.62 ± 3.9	0.31
RMPI		0.85 ± 0.29	0.66 ± 0.29	0.005
S` /RMPI index		12.42 ± 6.18	16.9 ± 8.42	0.008

* TAPSE: Tricuspid Annular Plane Systolic Excursion; PW-DTI: Pulsed Wave-Doppler Tissue Imaging; RMPI: right ventricular myocardial performance index; S`: Peak systolic; E`: peak early diastolic velocities; A`: late diastolic velocities of lateral tricuspid annulus

** PCI: Percutaneous Coronary Intervention

The comparison of RV myocardial function before and after PCI among studied cases with RCA affection were demonstrated in Table 3. A` wave velocities and RMPI showed high significant improvement by DTI ($P<0.001$). Systolic peak velocities showed high significant improvement ($P<0.001$). E` wave velocities was significant improvement (P=0.01) by color-coded doppler.

The comparison of RV myocardial function before and After PCI among studied cases with LAD affection was shown in Table 4. TAPSE showed significant improvement after PCI (P=0.02). There was significant improvement in E' wave velocities, RMPI and S`/RIMP were (P=0.02), (P=0.02) and (P=0.002), respectively. There was significant improvement in S' wave velocities at apex RMPI and S`/RIMP by color-coded Doppler image (P=0.01), (P=0.005) and (P=0.008), respectively.

DISCUSSION

This study showed a significant improvement in TAPSE (P=0.001) which in agreement with previous study showed that the mean score of TAPSE significantly increased from 18.68±2.12 to 20.40±2.11 ($P<0.001$).[21]

In this study, a non-significant improvement (P=0.5) in tissue Doppler measures of (S`) wave velocities was detected in comparison with baseline values by using right ventricle TDI. While, there was significant increase the right ventricle in early (E`) and late diastolic (A`) myocardial velocities after intervention (P= 0.002) and (P= 0.013), respectively. These results was in concordance with previous report by Diller *et al.* (2009) that proved Tissue Doppler parameters of diastolic and systolic function improve early after successful PCI and this effect persists to 6 weeks after intervention.[22] Likewise, by using Color-coded Doppler the (E`) basal RV free wall were improved significantly after PCI (P= 0.02) while (A`) basal RV free wall showed non-significant improvement (P= 0.8).

This study revealed statistically significant improvement in RV MPI by TDI (P= 0.008) and by using Color-coded Doppler (P= 0.01) that confirm the improvement of RMPI after PCI whatever the echo modality used.

In-patients with RCA intervention, the results of the current study revealed a highly significant change in MPI following the procedure detected by TDI ($P<0.001$). Moreover, the changes of TAPSE following PCI were not significant (P=0.27). These results are similar to that reported by Nikdoust *et al*. (2014) which revealed a significant improvement was found in RV function, but not LV function, after right coronary PCI.[23] In addition to these results the RV regional color-coded tissue Doppler parameters showed a highly significant improvement in both basal and mid cavity systolic wave velocities ($P<0.001$) and early diastolic E` velocities (P=0.01). Analysis of the effect of target vessel revascularization on RV longitudinal function in the current study shows that although improvements in right ventricular longitudinal function tended to be more pronounced in patients undergoing PCI of the RCA, Right ventricular function improved even in patients without revascularization within the RCA territory. This is in concordance with Diller *et al*. (2009).[22]

Many explanations may be responsible for improvement of RV function after the intervention. The direct effect of increased blood supply to the RV because of successful PCI to RCA territory.

In patients with LAD intervention, the results of this study showed significant improvement in TAPSE after PCI (P=0.02), E' (P= 0.02), systolic peak velocities by TDI (P=0.002), RMPI by both DTI and color-coded Doppler at the basal segment of the RV free wall was (P= 0.02) and (P= 0.005), respectively. S`/RMPI index DTI and color-coded Doppler were (P=0.002) and (P= 0.008), respectively.

The clarification of favorable outcome of RV function improvement after PCI to non RCA lesions was RV function improves as a consequence of augmented left ventricular function (ventriculo-ventricular interaction), affecting biventricular geometry or improved left ventricular diastolic function and leading to reduced RV after load.

The anterior wall of the RV is supplied by branches of the LAD[24] and autopsy studies had revealed that acute LAD occlusion could also cause partial RV infarction.[25] Systolic dysfunction of IVS and systolic ventricular interaction, impaired relaxation of LV and diastolic ventricular interaction, annular interaction, pericardial interaction effect of tethered LV anterior myocardium.[26] The study conducted by Mittal *et al*. reported that Left ventricular anterior myocardial infarction due to isolated occlusion of LAD is accompanied by impairment of diastolic DTI parameters in all segments of RV more so along medial and lateral tricuspid annulus, impairment of systolic DTI parameters along Tricuspid annulus and lateral and anterior wall of RV and "Myocardial interaction" can explain these observations.[27]

CONCLUSION

A significant improvement was found in the RV function after PCI not restricted only to the right coronary artery (RCA) revascularization but the improvement extend also to the patients with the intervention to the non-RCA lesions. Measurements performed by using color-coded DTI derived myocardial velocities at basal, mid and apical might have added additional data describing RV function and its recovery after RV ischemia.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Author Contributions

M.A.S., A.H.E., E.M.M., E.E.E., A.H.A. and G.F.G.: research plan design, data collection and manuscript writing. M.A.S., A.H.E., E.M.M. and E.E.E.: acquisition, analysis and interpretation of data; A.H.E., A.H.A. and G.F.G: participated in manuscript revision. All authors have read and approved the manuscript and the full disclosure of any relationship with industry is declared.

ABBREVIATIONS

CABG: Coronary Artery Bypass Grafting; **CTDI:** Colored Tissue Doppler Imaging; **DM:** Diabetes Miletus; **ECG:** Electrocardiograph; **ET:** Ejection Time; **HDL:** High Density Lipoprotein; **ICT:** Iso-volumic Concentration Time; **IHD:** Ischemic Heart Disease; **IRT:** Iso-volumic Relaxation Time; **LAD:** Left Anterior Descending; **LCx:** Left Circumflex; **RCA:** Right Coronary Artery; **LDL:** Low Density Lipoprotein; **LV:** Left Ventricular; **MPI:** Myocardial Performance Index; **MRI:** Magnetic Resonance Imaging; **PCI:** Percutaneous Coronary Intervention; **PW-DTI:** Pulsed Wave-Doppler Tissue Imaging; **PWD:** Pulsed Wave Doppler; **RMPI:** right ventricular myocardial performance index; **S`:** Peak systolic; **E`:** peak early diastolic velocities; **A`:** late diastolic velocities of lateral tricuspid annulus; **RV:** Right Ventricular; **TAPSE:** Tricuspid Annular Plane Systolic Excursion.

SUMMARY

Measurements carried out using color-coded Doppler tissue indices derived myocardial velocities at basal, mid and apical, might be added additional data describing RV function and its recovery after RV ischemia. A significant improvement was showed in the RV function after PCI n to the right coronary artery (RCA) revascularization and to the patients with the intervention to the non-RCA lesions.

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