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Original Article

Right Ventricular Functional Assessment in Acute Myocardial Infarction Using Strain Imaging Parameters and Its Angiographic Correlation

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Abstract

Introduction: Echocardiographic right ventricle (RV) functional parameters have independent and additive prognostic value in patients with left ventricle (LV) dysfunction following acute myocardial infarction (AMI) strain echocardiography is known to be a reliable method for the quantification of regional contractile dysfunction with the ability to detect subclinical cardiac dysfunction, and it is a feasible tool to evaluate RV global and regional myocardial function. It can measure RV systolic function in a non geometric manner like its evaluation of LV systolic function. Strain imaging has been proposed as an objective and quantitative measurement of wall motion abnormalities.

The Aim of Our Study: To correlate RV strain parameters with clinical, echocardiographic, and angiographic parameters.

Materials and Methods: Echocardiography was performed immediately after thrombolysis in patients with AMI using GE VIVID T8 machine, 3 Sc-Rs transducer adult probe equipped with tissue Doppler and speckle-tracking technology. RV strain assessment was done by speckle-tracking method. Coronary angiogram was performed in all patients included in the study.

Results: A total of 102 consecutive patients admitted in our Integrated Critical Care Unit with the first episode of AMI were included in our study. Among 102 patients, 80 (78%) were male and 22 (22%) were female. Anterior wall MI (AWMI) was more common (58%), inferior wall MI (IWMI) (40%), left ventricular mass index (LWMI) (2%). 40 patients out of the total 102 patients had single-vessel disease, 36 patients had double-vessel disease, and 8 patients had triple-vessel disease. A total of 14 patients had left main coronary artery involvement along with other vessel disease. In the study population, AWMI group had a mean mitral E/e' of 9.742 ± 3.421, IWMI group had a mean mitral E/e' of 10.556 ± 2.593, and LWMI group had a mean mitral E/e'of 9.57 ± 0.707. AWMI group had a mean RV mid-velocity of 3.986 ± 0.933. IWMI group had a mean RV mid-velocity of 3.385 ± 0.465. LWMI group has mean RV mid-velocity of 5.15 ± 1.626. AWMI group had a global RV mean velocity of 4.231 ± 1.281. IWMI group had a global RV mean velocity of 3.712 ± 0.591. LWMI group had a global RV mean velocity of 5.2 ± 0.849.

Conclusion: Patients with IWMI had much lower segmental and global longitudinal strain RV values compared to AMWI patients and the difference was statistically significant. RV dysfunction has also been related to poor prognosis; therefore, the function of both ventricles after AMI should be considered. Quantitative assessment of RV function with RV strain may improve the risk stratification of patients after AMI.

Key words: Quantitative right ventricular assessment, Right ventricular longitudinal strain, Speckle tracking

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INTRODUCTION

Acute myocardial infarction (AMI) is characterized by a loss of contractile tissue and a change in ventricle geometry that causes a substantial impairment of the right ventricle (RV) and left ventricle (LV) systolic and diastolic functions. Echocardiographic RV functional parameters

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have independent and additive prognostic value in patients with LV dysfunction.[1]

RV dysfunction may be primarily attributed to an abnormality of RV myocardium or secondary to LV dysfunction, as a consequence of "ventricular interdependence" between the two ventricles.[44] Hence, earliest recognition of RV dysfunction is warranted, but till today, it remains a challenging task because of complex structure and asymmetric shape of RV.[2] Subclinical RV dysfunction is known in patients with right coronary territory ischemia. Right ventricular functions in LV anterior infarction have been the subject of several studies but with significant discrepancies in results.[3-8] RV function is an important prognostic factor for clinical outcomes in patients with acute MI of LV. Moreover, RV involvement occurs in a percentage of patients suffering an inferior wall MI (IWMI) and increases in-hospital death rates.

Currently, strain and strain rate (S/SR) imaging is the most popular echocardiographic technique for use in AMI. Tissue Doppler imaging (TDI) and S/SR imaging are the most important modalities for revealing subclinical myocardial damage.[9]

Strain echocardiography is known to be a reliable method for the quantification of regional contractile dysfunction with the ability to detect subclinical cardiac dysfunction, and it is a feasible tool to evaluate RV global and regional myocardial function.[10] It can measure RV systolic function in a non-geometric manner like its evaluation of LV systolic function.[11] Strain imaging has been proposed as an objective and quantitative measurement of wall motion abnormalities. Regional myocardial strain can be measured by velocity gradient from TDI. However, TDI is Doppler angle-dependent, which makes the acquisition and correct interpretation of the data more difficult.

The aim of our study was to evaluate RV regional functions using speckle tracking, diffusion tensor imaging (DTI)-derived S/SR imaging method in patients who experienced their first successfully treated AMI.

Aim of the Study

- To evaluate right ventricular regional functions using a derived strain and strain rate imaging by speckle-tracking/tissue Doppler method in patients who were successfully treated for their first AMI
- To correlate RV strain parameters with clinical and echocardiographic parameters.

To analyze angiographic results of the same patients in the study group.

MATERIALS AND METHODS

Study Population

One hundred and two patients who had suffered their first acute MI attack had been hospitalized within 1–12 h of the onset of symptoms and had undergone thrombolysis were enrolled in the study at Intensive Cardiac Care Unit, Government Rajaji Hospital.

Inclusion Criteria

One hundred and two patients suffering from first AMI who had been hospitalized within 1–12 h of the onset of symptoms and had undergone thrombolysis were enrolled in the study.

Exclusion Criteria

The exclusion criteria were as follows:

- Patients with:
  - Bundle branch block
  - A prior history of MI
  - Prior percutaneous transluminal coronary angioplasty or undergone recurrent percutaneous intervention
  - Acute stent thrombosis.
- Patients with pulmonary hypertension due to:
  - Valvular heart disease
  - Lung disease
  - Cardiomyopathy
  - Renal, hepatic, hematological disorders
  - Malignancy.

Data Collection

A detailed medical history, clinical examination, and relevant laboratory investigations were done as indicated in each patient.

Study Protocol

Design of study

The study was a prospective analytical study.

Period of study

This study was conducted from August 2015 to February 2016.

Collaborating departments

Department of Cardiology.

Ethical clearance

The ethical clearance was obtained.

Consent

Individual written and informed consent was obtained.

Analysis: Statistical Analysis

Data analysis was done with the help of computer using SPSS 16 software and Sigma Stat 3.5 version (2012). Using

this software, mean, standard deviation, and "*P*" value were calculated through Student's *t*-test, One-way ANOVA, Chi-square test, and correlation coefficient from Pearson correlation and $P < 0.05$ was considered as statistically significant.

Echocardiogram

Echocardiography was performed immediately after thrombolysis in patients with AMI using GE VIVID T8 machine, 3 Sc-Rs transducer adult probe equipped with tissue Doppler and speckle-tracking technology.

LV systolic function was assessed by modified Simpson's method. Pulse Doppler was used to assess mitral E/A, tricuspid E/A. Mitral E/e' was assessed by TDI.

RV strain assessment was done by speckle-tracking method. The image acquisitions are based on detecting speckles from the myocardium with two-dimensional echocardiography analyzing motion in different directions, longitudinal, radial, and circumferential. Strain measurements of the RV are best performed from the apical four-chamber view, assessing the RV free wall from the base to the apical level.

RV myocardial velocity, strain, and strain rate was assessed by TDI method. One-dimensional strain echocardiography is a dimensionless measurement that represents the fractional or percentage change in myocardial fiber shortening. To calculate strain, high frame rates are required, ideally ≥150 frames/s. As such, a narrow imaging sector focusing on the RV free wall is desired. Care should be taken to align the segment in the center of the sector to avoid errors due to the angle dependence of Doppler. A maximum tolerance of 10–15° of the axis is recommended.. Imaging is in color-coded tissue Doppler mode, and ≥3 beats are acquired with suspended respiration. Values for strain and SR are then derived offline on the system or workstation using equipment-specific algorithms by placing sample volume(s) or regions of interest of varying sizes in the mid-portion of the segment(s).

Coronary Angiogram

Coronary angiogram was performed in all patients included in the study after getting informal consent.

Standard accesses chosen were either femoral or radial approach. Standard views for coronary angiogram included AP, left anterior oblique, right anterior oblique caudal and cranial views.

RESULTS

A total of 102 consecutive patients admitted in our Integrated Critical Care Unit with the first episode of AMI were included in our study. Among 102 patients, 80 (78%) were male and 22 (22%) were female. Anterior wall MI (AWMI) was more common (58%), IWMI (40%), left ventricular mass index (LWMI) (2%). 39 patients were <50 years and 63 patients were >50 years. Among patients presenting with AMI, 69 (68%) were smokers and 33 (32%) were non-smokers. 45 (44.1%) were diabetics and 57 (55.9%) were non-diabetics. Similarly, 45 (44.1%) were hypertensives and 57 (55.9%) were non-hypertensives. 102 patients had single-vessel disease (SVD), 36 patients had double-vessel disease (DVD), and 8 patients had triple-vessel disease (TVD). A total of 14 patients had left main coronary artery (LMCA) involvement along with other vessel disease. A total of 3 patients with AWMI had recanalized left anterior descending (LAD).

A total of 37 patients with AWMI had underwent percutaneous coronary intervention (PCI), while 10, 12 patients opted for coronary artery bypass surgery (CABG), medical management respectively. Similarly, 20 patients with IWMI had underwent PCI, while 21, 0 patients opted for CABG, medical management, respectively. In the same manner, two patients with LWMI had underwent PCI. AWMI group had a mean left ventricular ejection fraction (LVEF) of 39.37 ± 4.881%. IWMI group had a mean LVEF of 41.43 ± 6.091%. LWMI group had a mean LVEF of 47 ± 11.31%. The difference between the groups was statistically significant. In the study population, AWMI group had a mean mitral E/A of 1.036 ± 0.369. IWMI group had a mean mitral E/A of 1.005 ± 0.249. LWMI group had a mean mitral E/A of 0.7 ± 0.283. The difference between the groups was statistically insignificant. In the study population, AWMI group had a mean mitral E/e' of 9.742 ± 3.421, IWMI group had a mean mitral E/e' of 10.556 ± 2.593, and LWMI group had a mean mitral E/e'of 9.57 ± 0.707. The difference between the groups was statistically insignificant. AWMI group had a mean tricuspid E/A of 1.131 ± 0.317. IWMI group had a mean tricuspid E/A of 0.98 ± 0.299. LWMI group had a mean tricuspid E/A 0.6 ± 0.283. The difference between the groups was statistically significant. In the study population, AWMI group had a mean tricuspid annular plane systolic excursion (TAPSE) of 16.763 ± 2.68. IWMI group had a mean TAPSE of 14.049 ± 1.923. LWMI group had a mean tricuspid E/A 15. Age group <50 years had a mean RV strain of −14.26 ± 2. Age group >50 years had a mean RV strain of −14.49 ± 2.29. Similarly age group <50 years had a mean RV strain rate of −1.51 ± 0.23. Age group >50 years had a mean RV strain rate of −1.43 ± 0.18. In the study population, males had a mean RV strain of −14.25 ± 2.24 and females had a mean RV strain of −14.98 ± 2.05. Similarly, males had a mean RV strain rate of −1.47 ± 0.21 and females had a mean RV strain rate of −1.43 ± 0.16. Smokers group had a mean RV strain of

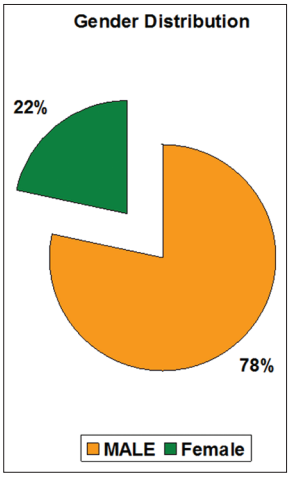
−14.17 ± 2.04. Non-smokers group had a mean RV strain of −14.89 ± 2.51. Similarly, smokers group had a mean RV strain rate of −1.47 ± 0.21. Non-smokers group had a mean RV strain rate of −1.44 ± 0.17.

Diabetics group had a mean RV strain of −14.34 ± 2.46 and nondiabetics group had a mean RV strain of −14.46 ± 2.02. Similarly, diabetics group had a mean RV strain rate of −1.44 ± 0.18 and non-diabetics group had a mean RV strain rate of −1.47 ± 0.22. In the study population, hypertensive group had a mean RV strain of −13.81 ± 2.73 and non-hypertensive group had a mean RV strain of −14.87 ± 1.57. Similarly, hypertensive group had a mean RV strain rate of −1.45 ± 0.22 and nonhypertensive group had a mean RV strain rate of −1.46 ± 0.19. The difference between the groups was statistically insignificant. In the study population, AWMI group had a mean RV basal velocity of 6.536 ± 2.442. IWMI group had a mean RV basal velocity of 5.854 ± 0.686. LWMI group had a mean RV basal velocity of 7.55 ± 0.778. AWMI group had a mean RV mid-velocity of 3.986 ± 0.933. IWMI group had a mean RV mid-velocity of 3.385 ± 0.465. LWMI group has mean RV mid-velocity of 5.15 ± 1.626. Similarly, AWMI group had a global RV mean velocity of 4.231 ± 1.281. IWMI group had a global RV mean velocity of 3.712 ± 0.591. LWMI group had a global RV mean velocity of 5.2 ± 0.849.

AWMI group had a mean RV basal strain rate of −2.02 ± 0.3. IWMI group had a mean RV basal strain rate of −1.773 ± 0.118. LWMI group had a mean RV basal strain rate of −1.95 ± 0.354. Similarly, AWMI group had a mean RV mid-strain rate of −1.656 ± 0.237. IWMI group had a mean RV mid-strain rate of −1.359 ± 0.086. LWMI group had a mean RV mid-strain rate of −1.55 ± 0.354. AWMI group had a mean RV apex strain rate of −1.032 ± 0.245. IWMI group had a mean RV apex strain rate of −0.784 ± 0.096. LWMI group had a mean RV apex strain rate of −1.2 ± 0.424. Similarly, AWMI group had a global RV mean strain rate of −1.563 ± 0.194. IWMI group had a global RV mean strain rate of −1.302 ± 0.046. LWMI group had a global RV basal strain rate of −1.55 ± 0.354. Global RV strain showed high correlation with LV function assessed by LVEF in our study population. However, global RV strain rate showed low correlation with LVEF.

Table 1: Results sex

Sex	Number of patients
Male	80
Female	22
Total	102

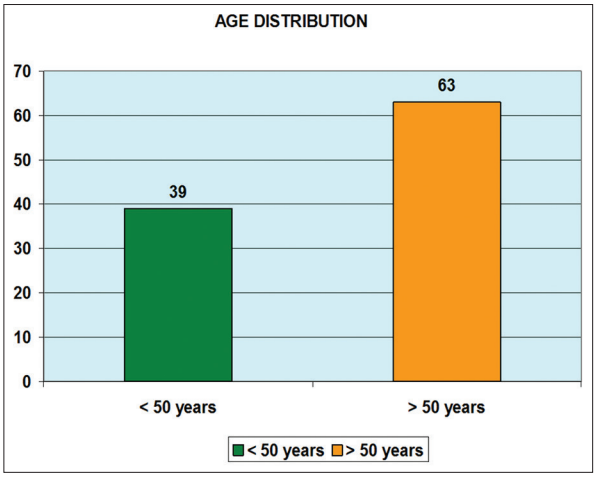


In this study, there were 80 male patients and 22 female patients. [Table 1]

Table 2: Age

Age	Number of patients
<50 years	39
>50 years	63
Total	102

In this study, there were 63 patients above 50 years



In this study, there were 63 patients above 50 years [Table 2]

DISCUSSION

RV Strain, on Comparison with Various Clinical Characteristics

Age and RV strain [Table 12a]

In this study, there was no significant association detected between age and RV strain values. In the review of literature, no independent association could be detected between age and RV strain.[12,13] In their study of 44 patients with acute AWMI, Sonmez *et al*.[14] found no independent association between age and RV strain.

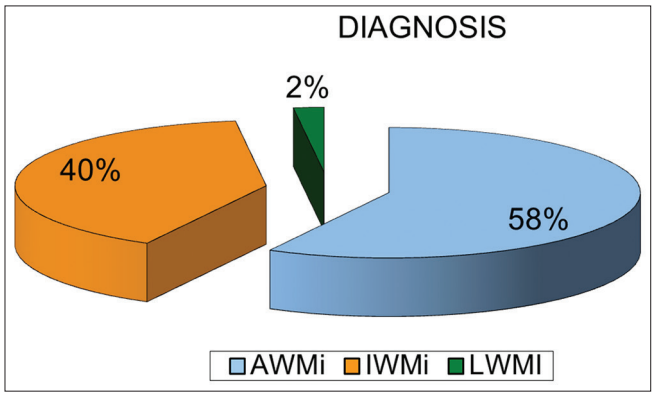
Gender and RV strain [Table 13a]

In this study, there was no significant association detected between gender and RV strain values. In the review of

Table 3: Diagnosis

Diagnosis	Number of patients
AWMI	59
IWMI	41
LWMI	2
Total	102

AWMI: Anterior wall myocardial infarction, IWMI: inferior wall myocardial infarction, LWMI: Left ventricular mass index

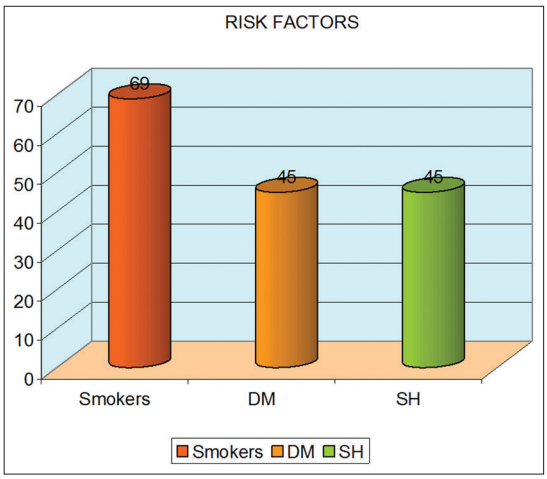


In our study, 59 anterior wall myocardial infarction patients included, and there is 41 inferior wall myocardial infarction patients and 2 lateral wall myocardial infarction are included [Table 3]

Table 4: Risk factors

Risk factors	Number of cases
Smokers	69
DM	45
SH	45

DM: Diabetes mellitus, SH: Systemic hypertension



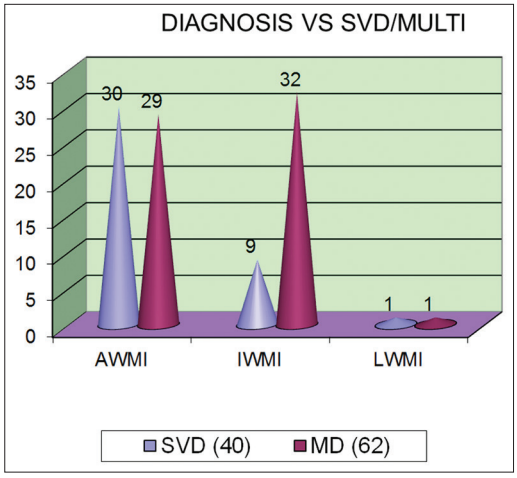
In our study there were 69 smokers ,45 patients had Diabetes and hypertension [Table 4]

literature, no independent association could be detected between gender and RV strain.[12,13] In their study of 145 patients with STEMI, Huttin *et al*.[15] stated no significant independent association between gender and RV strain.

Table 5: Coronary angiogram

Impression	AWMI	IWMI	LWMI	Total
DVD	17	18	1	36
LMCA+DVD	1	13	0	14
Recanalized LAD	3	0	0	3
SVD	30	9	1	40
TVD	8	1	0	8
Total	59	41	2	102

AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, DVD: Double-vessel disease, LMCA: Left main coronary artery, LAD: Left anterior descending, SVD: Single-vessel disease, TVD: Triple-vessel disease



In our study 40 patients had single vessel disease,36 patients had double vessel disease,14 patients had LMCA+DVD,8 patients had TVD, AND 3 patients had recanalised LAD [Table 5]

Smoking and RV strain [Table 14a]

In this study, there was no significant association detected between smoking and RV strain values.

In the review of literature, no independent association could be detected between smoking and RV strain.[12,13]

Diabetes and RV strain [Table 15a]

In this study, there was no significant association detected between smoking and RV strain values. In various studies done using RV strain in MI patients, no independent significant association could be detected between diabetes and RV strain [Table 4].[16]

Hypertension and RV strain [Table 16a]

Hypertensive group had a mean RV strain of −13.81 ± 2.73. Nonhypertensive group had a mean RV strain of −14.87 ± 1.57. The difference between the groups was statistically significant. The patients with LV systolic and diastolic dysfunction had significant RV dysfunction detected by RV strain. Abatte *et al*. showed remarkable RV cardiomyocyte apoptosis in the setting of AMI of the left ventricular wall. This apoptosis could be due to myocardial edema. Grothoff and Jensen *et al*.[10,12] revealed considerable edema in the RV of patients with anterior MI in their MRI studies.

ECHO Characteristics

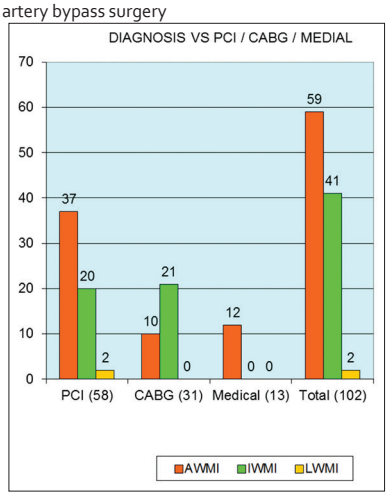
LVEF [Table 7]

In the study population, AWMI group had a mean LVEF of 39.37 ± 4.881%, IWMI group had a mean LVEF of 41.43 ± 6.091%, and LWMI group had a mean LVEF of 47 ± 11.31%.

Table 6: Treatment modalities

Treatment modalities	AWMI	IWMI	LWMI	Total
PCI	37	20	2	59
CABG	10	21	0	31
Medical	12	0	0	12
	59	41	2	102

AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, PCI: Percutaneous coronary intervention, CABG: Coronary artery bypass surgery

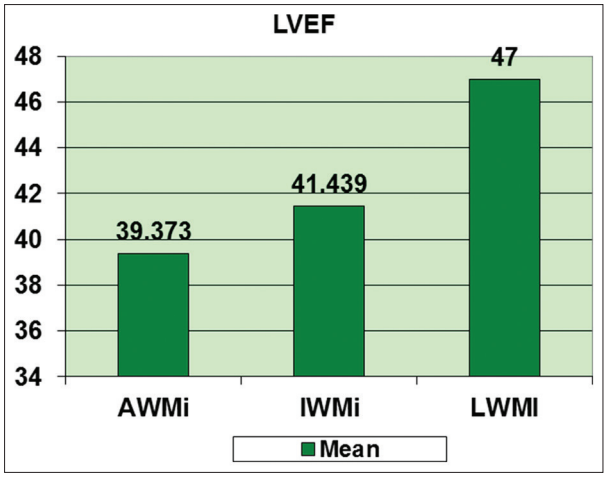


In our study 59 patients had undergone PCI, CABG was done for 31 patients and 12 patients received optical medical treatment. [Table 6]

Table 7: LVEF

LVEF	Mean±SD
AWMI	39.373±4.881
IWMI	41.439±6.091
LWMI	47±11.314

LVEF: Left ventricular ejection fraction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation



Mitral E/A [Table 8]

In the study population, AWMI group had a mean mitral E/A of 1.036 ± 0.369, IWMI group had a mean mitral E/A of 1.005 ± 0.249, and LWMI group had a mean mitral E/A of 0.7 ± 0.283. The difference between the groups was statistically insignificant. In the review of literature, mitral E/A of patients with AMI was significantly lower than control population.[14]

Table 8: Mitral E/A

Mitral E/A	Mean±SD	*P*
AWMI	1.036±0.369	0.050
IWMI	1.005±0.249	0.344
LWMI	0.7±0.283	0.512

AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

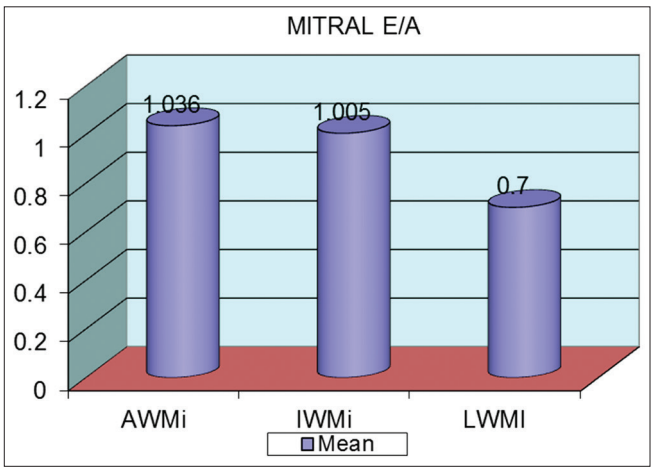


Table 9: Mitral E/e'

Mitral E/e'	Mean±SD	*P*
AWMI	9.742±3.421	0.121
IWMI	10.556±2.593	0.422
LWMI	9.5±0.707	0.644

AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

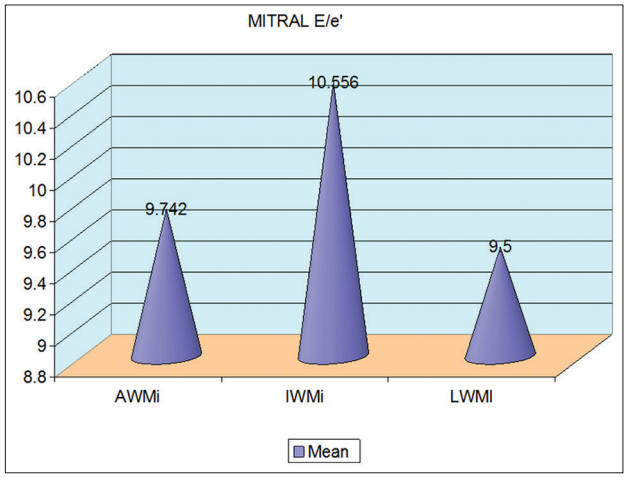


Table 10: Tricuspid E/A

Tricuspid E/A	Mean±SD	*P*
AWMI	1.131±0.317	0.522
IWMI	0.98±0.299	0.008
LWMI	0.6±0.283	0.988

AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

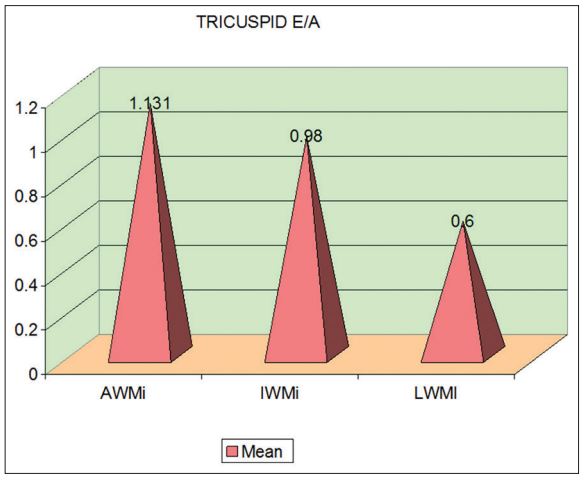
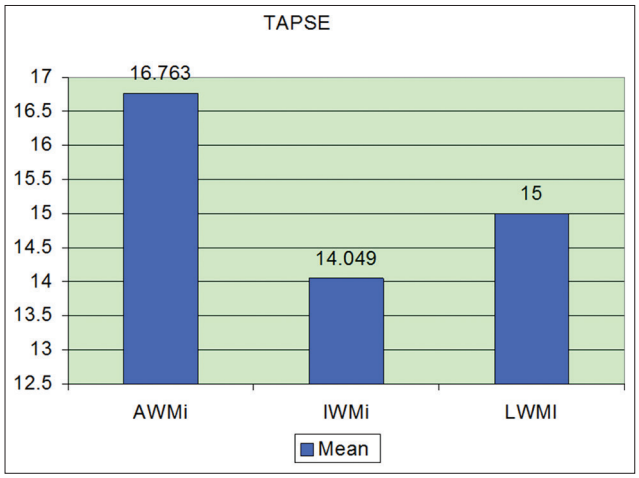


Table 11: TAPSE

TAPSE	Mean±SD	*P*
AWMI	16.763±2.68	0.044
IWMI	14.049±1.923	<0.001
LWMI	15±0	N.S.

AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation, TAPSE: Tricuspid annular plane systolic excursion



Mitral E/e' [Table 9]

In our study population, patients with AMI had high E/e', AWMI group had a mean mitral E/e' of 9.742 ± 3.421, and IWMI group had a mean mitral E/e' of 10.556 ± 2.593. In their study of 44 patients with acute AWMI, Sonmez *et al.* stated that with regard to conventional echocardiographic parameters, the mitral E/E' were significantly higher in the patient group.[14]

Table 12: Age and RV strain

Age versus RV strain	Mean±SD	*P*
<50 years	−14.26±2.2	0.618
>50 years	−14.49±2.27	0.222

RV: Right ventricle, SD: Standard deviation

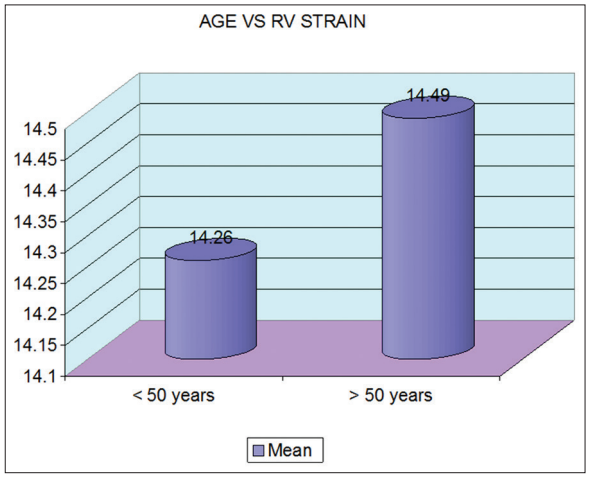
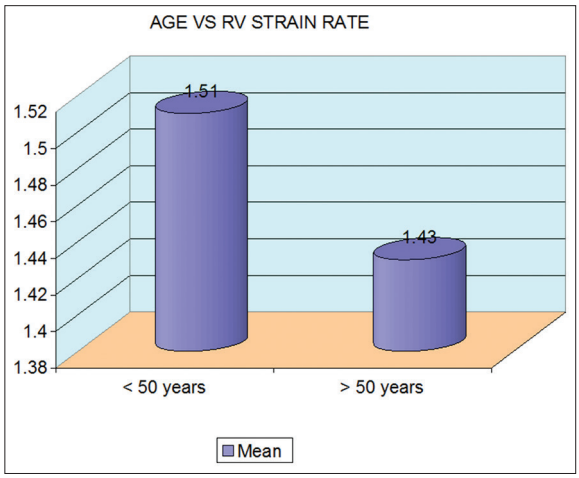


Table 12a: Age and RV strain

Age versus RV strain rate	Mean±SD	*P*
<50 years	−1.51±0.23	0.062
>50 years	−1.43±0.18	0.424

RV: Right ventricle, SD: Standard deviation



Tricuspid E/A [Table 10]

In the study population, AWMI group had a mean tricuspid E/A of 1.131 ± 0.317. IWMI group had a mean tricuspid E/A of 0.98 ± 0.299. In their study of 44 patients with acute AWMI, Sonmez *et al.*[14] stated that tricuspid E/A did not vary significantly between AWMI patients and control group. In this study, there was a significant difference between AWMI patients and IWMI patients.

Table 13: Gender and RV strain

Sex versus RV strain	Mean±SD	*P*
Male	−14.25±2.24	0.166
Female	−14.98±2.05	0.544

RV: Right ventricle, SD: Standard deviation

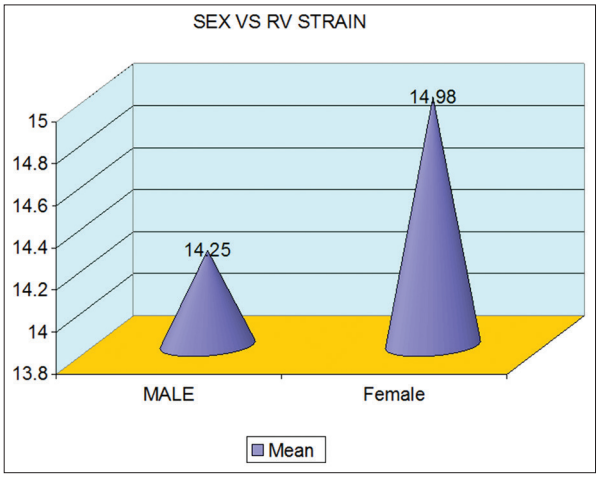
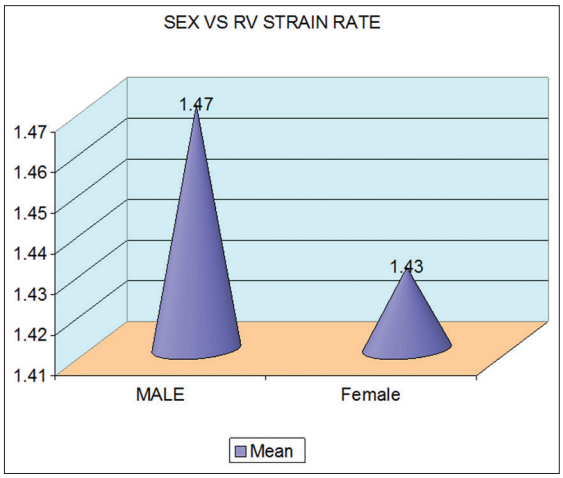


Table 13a: Gender and RV strain

Sex versus RV strain rate	Mean±SD	*P*
Male	−1.47±0.21	0.464
Female	−1.43±0.16	0.424

RV: Right ventricle, SD: Standard deviation



In the study population, males had a mean right ventricle (RV) strain of −14.25±2.24 and females had a mean RV strain of −14.98±2.05. The difference between the groups was statistically in significant. Similarly, males had a mean RV strain rate of −1.47±0.21 and females had a mean RV strain rate of −1.43±0.16. The difference between the groups was statistically insignificant.

Table 14: Smoking and RV strain [Tables 14 and 14a, Figures 9 and 10]

Smokers versus RV strain	Mean±SD	*P*
Smokers (69)	−14.17±2.04	0.125
Non-smokers (33)	−14.89±2.51	0.544

RV: Right ventricle, SD: Standard deviation

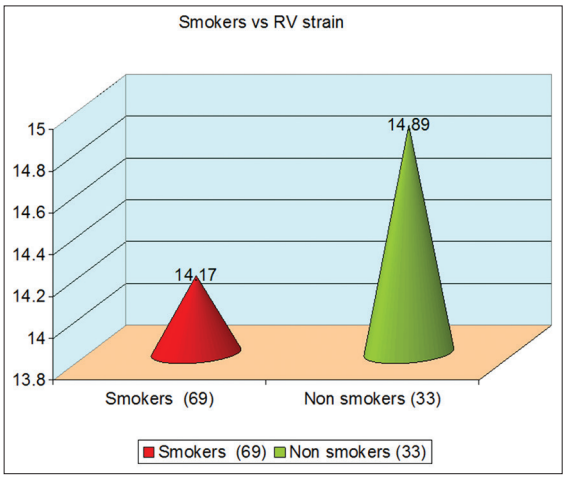
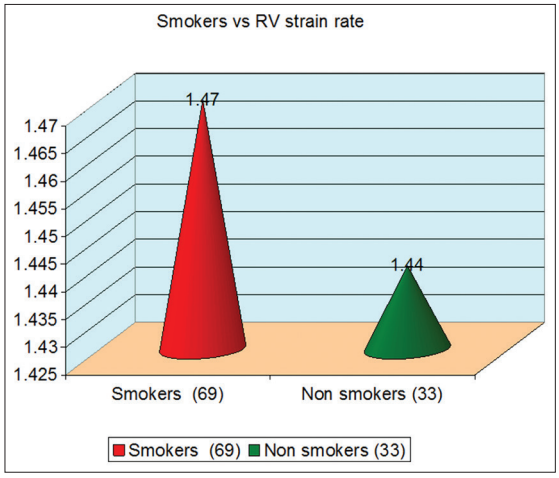


Table 14a: Smoking and RV strain [Tables 14 and 14a, Figures 9 and 10]

Smokers versus RV strain rate	Mean±SD	*P*
Smokers (69)	−1.47±0.21	0.496
Non-smokers (33)	−1.44±0.17	0.864

RV: Right ventricle, SD: Standard deviation



In our study mean strain and strain rate in smokers were −14.17±2.04 and −1.47±0.21 and in non smokers were −14.89±2.51 and −1.44±0.17 [Table 14,14a]

TAPSE [Table 11]

In the study population, AWMI group had a mean TAPSE of 16.763 ± 2.68. IWMI group had a mean TAPSE of 14.049 ± 1.923. The difference between the groups was statistically significant ($P < 0.001$).

In their study of 282 consecutive IWMI patients, Park *et al.* concluded that global longitudinal strain of the RV (GLSRV) showed significant correlations with conventional echocardiographic indicators of RV systolic function, including right ventricular fractional area change (RVFAC) and TAPSE.

Table 15: Diabetes and RV strain

DM versus RV strain	Mean±SD	*P*
DM (45)	−14.34±2.46	0.777
NO DM (57)	−14.46±2.02	0.122

RV: Right ventricle, SD: Standard deviation, DM: Diabetes mellitus

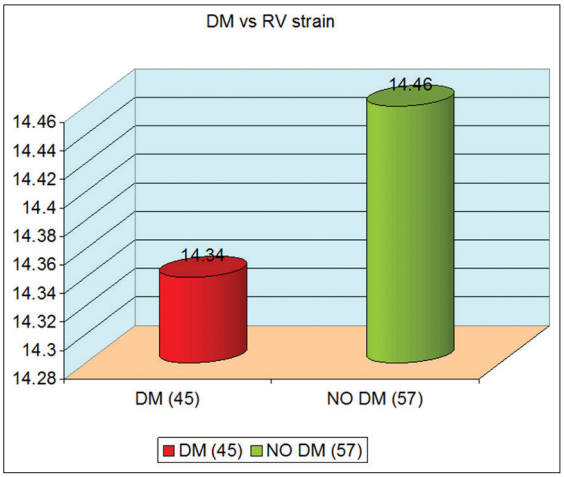
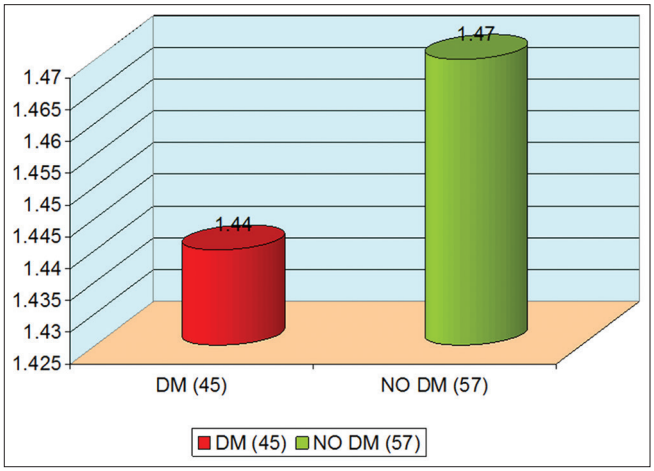


Table 15a: Diabetes and RV strain

DM versus RV strain rate	Mean±SD	*P*
DM (45)	−1.44±0.18	0.487
NO DM (57)	−1.47±0.22	0.988

RV: Right ventricle, SD: Standard deviation, DM: Diabetes mellitus



In our study mean strain and strain rate in DM patients were −14.34±2.46,-1.44+ 0.18 and in non DM patients were −14.46±2.02 and -1.44+0.22 [Table 15,15a]

In this study, IWMI patients had a mean TAPSE of 14.049 ± 1.923 indicating the presence of RV dysfunction in most of the patients.

RV Strain Imaging

RV myocardial velocity [Tables 17a-c]

In the study population, AWMI group had a mean RV basal velocity of 6.536 ± 2.442. IWMI group had a mean RV basal velocity of 5.854 ± 0.686.

Table 16: Hypertension and RV strain

SH versus RV strain	Mean±SD	*P*
SH (45)	−13.81±2.73	0.015
NO SH (57)	−14.87±1.57	0.004

RV: Right ventricle, SD: Standard deviation, SH: Systemic hypertension

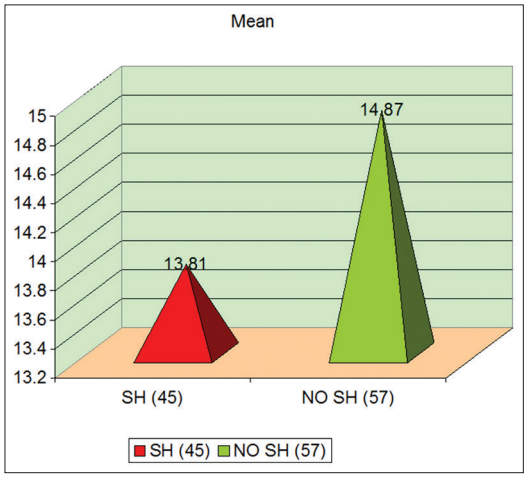
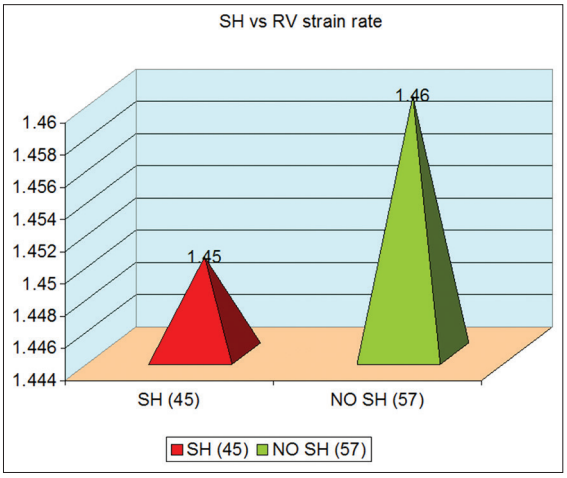


Table 16a: Hypertension and RV strain

SH versus RV strain rate	Mean±SD	*P*
SH (45)	−1.45±0.22	0.78
NO SH (57)	−1.46±0.19	0.422

RV: Right ventricle, SD: Standard deviation, SH: Systemic hypertension



In our study mean strain and strain rate in HTN patients were −13.81±2.73 and−1.45±0.22 In non HTN patients−14.87±1.57 and −1.46±0.19 [Table 16,16a]

Similarly, AWMI group had a mean RV mid-velocity of 3.986 ± 0.933 and IWMI group had a mean RV mid-velocity of 3.385 ± 0.465. The difference between the groups was statistically significant ($P < 0.001$).

Similarly, AWMI group had a global RV mean velocity of 4.231 ± 1.281 and IWMI group had a global RV mean velocity of 3.712 ± 0.591. The difference between the groups was statistically significant.

Table 17: RV velocity in AMI

RV velocity (basal)	Mean±SD	*P*
AWMI	6.536±2.442	0.224
IWMI	5.854±0.686	0.145
LWMI	7.55±0.778	0.422

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

Table 17a: RV velocity in AMI

RV velocity (mid)	Mean±SD	*P*
AWMI	3.986±0.933	0.644
IWMI	3.385±0.465	<0.001
LWMI	5.15±1.626	0.224

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

Table 17b: RV velocity in AMI

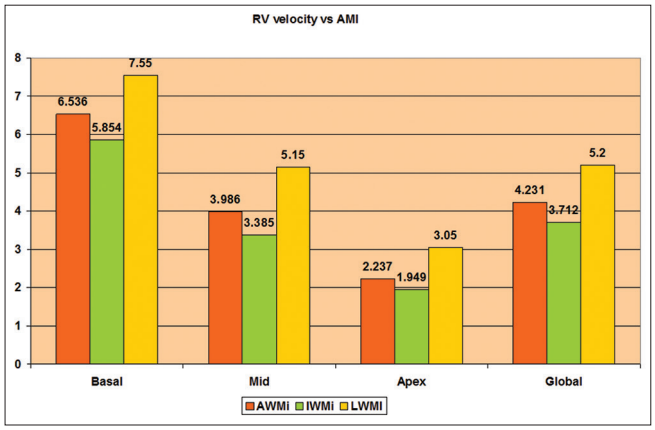
RV velocity (apex)	Mean±SD	*P*
AWMI	2.237±0.934	0.422
IWMI	1.949±0.78	0.091
LWMI	3.05±0.0707	0.488

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

Table 17c: RV velocity in AMI

RV velocity (global)	Mean±SD	*P*
AWMI	4.231±1.281	0.822
IWMI	3.712±0.591	0.018
LWMI	5.2±0.849	0.001

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation



In their study of 44 patients with AWMI by Sonmez *et al*.[14] stated decrease in the mean RV velocities were common in the study AWMI patients.

RV myocardial strain [Tables 18a-c]

In the study population, AWMI group had a mean RV basal strain of −20.475 ± 2.406 and IWMI group had a mean RV

Table 18: RV strain and AMI

RV strain (basal)	Mean±SD	*P*
AWMI	−20.475±2.406	0.622
IWMI	−17.829±2.936	<0.001
LWMI	−16±1.414	<0.001

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

Table 18a: RV strain and AMI

RV strain (mid)	Mean±SD	*P*
AWMI	−16.205±1.861	0.422
IWMI	−13.244±2.308	<0.001
LWMI	−12.5±0.707	0.622

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

Table 18b: RV strain and AMI

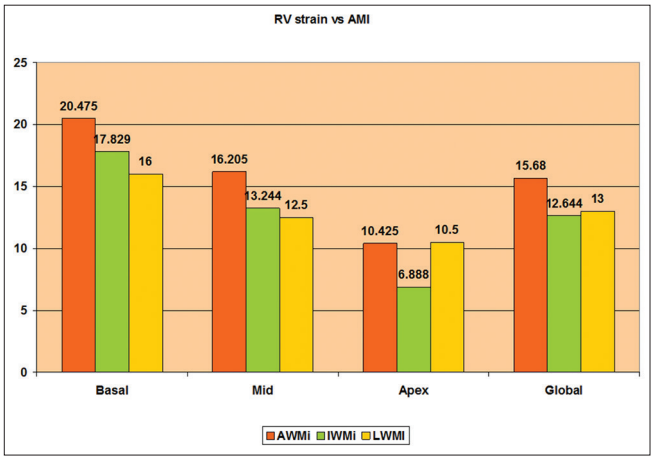
RV strain (apex)	Mean±SD	*P*
AWMI	−10.425±1.501	0.766
IWMI	−6.888±0.868	<0.001
LWMI	−10.5±3.536	0.922

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

Table 18c: RV strain and AMI

RV strain (global)	Mean±SD	*P*
AWMI	−15.68±1.521	0.422
IWMI	−12.644±1.811	<0.001
LWMI	−13±1.414	0.644

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation



basal strain of −17.829 ± 2.936. Similarly, AWMI group had a mean RV mid-strain of −16.205 ± 1.861. IWMI group had a mean RV mid-strain of −13.244 ± 2.308. AWMI group had a mean RV apex strain of −10.425 ± 1.501. IWMI group had a mean RV apex strain of −6.888 ± 0.868. The difference between the groups was statistically significant.

Table 19: RV strain rate and AMI

RV strain rate (basal)	Mean±SD	*P*
AWMI	−2.02±0.3	0.422
IWMI	−1.773±0.118	<0.001
LWMI	−1.95±0.354	0.644

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

Table 19a: RV strain rate and AMI

RV strain rate (mid)	Mean±SD	*P*
AWMI	−1.656±0.237	0.244
IWMI	−1.359±0.0865	<0.001
LWMI	−1.55±0.354	0.644

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

Table 19b: RV strain rate and AMI

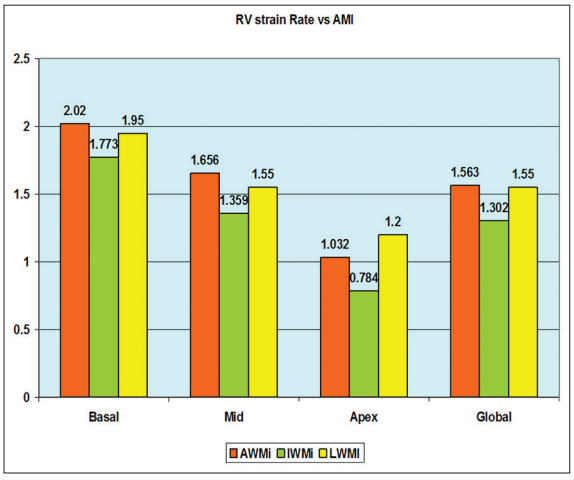
RV strain rate (apex)	Mean±SD	*P*
AWMI	−1.032±0.245	0.054
IWMI	−0.784±0.0968	<0.001
LWMI	−1.2±0.424	0.022

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation

Table 19c: RV strain rate and AMI

RV strain rate (global)	Mean±SD	*P*
AWMI	−1.563±0.194	0.242
IWMI	−1.302±0.0464	<0.001
LWMI	−1.55±0.354	0.422

RV: Right ventricle, AMI: Acute myocardial infarction, AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, LWMI: Left ventricular mass index, SD: Standard deviation



Similarly, AWMI group had a global RV mean strain of −15.68 ± 1.521 and IWMI group had a global RV mean strain of −12.644 ± 1.811. The difference between the groups was statistically significant.

Table 20: RV strain and LVEF

Correlation		
LVEF versus global RV strain	0.659	High correlation
LVEF versus global RV strain rate	0.083	Very low correlation

RV: Right ventricle, LVEF: Left ventricular ejection fraction

Table 20a: RV strain and LVEF

RV strain and TAPSE: Correlation		
TAPSE versus global RV strain	0.535	Good correlation
TAPSE versus global RV strain rate	0.329	Low correlation

RV: Right ventricle, LVEF: Left ventricular ejection fraction, TAPSE: Tricuspid annular plane systolic excursion

Strain echocardiography gives us objective information on global and regional RV systolic function. Since RV muscle fibers run longitudinally, longitudinal shortening generates 80% of the stroke volume, which makes it a major portion of RV systolic function.[17,18]

In their study of 145 patients with acute AMI, Huttin *et al.* stated that global RV strain was lower in IWMI than in AWMI.[15]

In their study of 64 patients with acute AWMI, Sonmez *et al.* stated that RV mid, apex strain/strain rate was significantly lower compared to control population.[14]

In their study of 82 consecutive patients with IWMI, Song *et al.* stated that all RV regional longitudinal strains are categorized into apical, mid, and basal levels. RV apical, mid, and basal longitudinal strains were significantly less in patients with IWMI than in controls.[19]

Local longitudinal parameters such as TAPSE and S' velocity failed to show any significant differences related to the location of MI at the acute phase in our patients, with relatively preserved RV function.[20] This is in accordance with other studies reporting a poor diagnostic power of conventional parameters for initial RV extension of MI.[21] RV dysfunction can be observed irrespective of the localization of MI.[22] Indeed, RV dysfunction has been observed in over 40% of inferior MI patients and in up to 33% of anterior MI. Huttin *et al.* showed a decrease of RV strain values in all MI locations albeit more substantial in inferior comparatively to anterior MI. In contrast, septal strain was similar in patients with inferior and anterior AMI. Huttin *et al.* demonstrated that our study indicated that RV strain is likely more efficient than other conventional parameters in detecting RV dysfunction in the acute phase of small and non-complicated MI.

RV myocardial strain rate [Tables 19a-c]

In the study population, AWMI group had a mean RV basal strain rate of −2.02 ± 0.3. IWMI group had a mean

RV basal strain rate of −1.773 ± 0.118. Similarly, AWMI group had a mean RV mid-strain rate of −1.656 ± 0.237. IWMI group had a mean RV mid-strain rate of −1.359 ± 0.086. AWMI group had a mean RV apex strain rate of −1.032 ± 0.245. IWMI group had a mean RV apex strain rate of −0.784 ± 0.096. Similarly, AWMI group had a global RV mean strain rate of −1.563 ± 0.194. IWMI group had a global RV mean strain rate of −1.302 ± 0.046. The difference between the groups was statistically significant. S/SR imaging is currently the most popular echocardiographic modality for revealing subclinical myocardial damage. In the literature, postmortem studies mention RV involvement after left ventricular infarction.

RV strain and LVEF, TAPSE

Global RV strain showed high correlation with LV function assessed by LVEF in our study population. However, global RV strain rate showed low correlation with LVEF.

Global RV strain showed good correlation with TAPSE[23] in our study population. However, global RV strain rate showed low correlation with LVEF.

In their study of 282 consecutive IWMI patients, Park *et al.* stated that GLSRV showed significant correlations with conventional echocardiographic indicators of RV systolic function, including RVFAC and TAPSE.[23]

Coronary Angiogram

In the study population consisting of 59 patients with AWMI, 30 (50.8%) had SVD involving LAD, 3 (5%) had recanalized LAD, 17 (28.8%) had DVD, 8 (13.5%) had TVD, and 1 (1.6%) had significant LMCA involvement. Essentially, all patients with AWMI had LAD involvement.

Of the 41 patients with IWMI, 9 (21.9%) had SVD involving RCA, 18 (43.9%) had DVD, 1 (2.4%) had TVD, and 13 (31.7%) had LMCA involvement with or without other vessel involvement. Essentially, all patients with IWMI in our study group had RCA involvement. Of the two patients with LWMI, 1 had SVD and 1 had DVD. Huttin *et al.* in their study had similar observation.[15]

Study Limitations

This study was a single-center study with small sample size.

Entry criterion for this study was AMI patients who have undergone thrombolysis. This may have introduced a selection bias. Doppler tissue imaging is dependent on the angle at which the region of interest is imaged, has increased signal-to-noise ratio. Overall, heart motion, cardiac rotation, and wall motion from tethering segments limit the use of DTI. RV strain is most reproducible in the apical four-chamber view, interrogating the basal, mid, and to a lesser degree, apical segments of the RV free wall. As a result, one is limited to mostly longitudinal strain. There is a lack of normative data regarding speckle-tracking technique, which also requires additional validation. Requiring additional software, it is dependent on adequate image quality. The global nature is derived only from a single view, making it not a truly global assessment of RV function. Prognosis of patients with RV dysfunction assessed by RV strain was not done in this study, but this study may open roads for further studies related to this area.

CONCLUSION

Global Longitudinal Strain of Right Ventricle showed significant correlations with conventional echocardiographic parameters of RV systolic function like TAPSE and also LV systolic function measured by LVEF. RV strain provides incremental value over clinical information, infarct characteristics, LV function, and TAPSE. There is significant RV dysfunction detected by RV strain imaging in patients presenting with AMI immediately after thrombolysis. In this study, AWMI patients had lowered segmental and GLSRV compared to reference normal values. Patients with IWMI had much lower segmental and GLSRV values compared to AMWI patients, and the difference was statistically significant.

RV dysfunction has also been related to poor prognosis; therefore, the function of both ventricles after AMI should be considered. RV assessment with these imaging modalities will have an increased value during treatment. Quantitative assessment of RV function with RV strain may improve the risk stratification of patients after AMI.

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