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ORIGINAL ARTICLE

Right Ventricular Systolic Function by 3D Echocardiography in Patients with Inferior Myocardial Infarction vs. without Right Ventricular Infarction; Compared with Normal Subjects

Running Title: Right Ventricular Systolic Function, 3D Echocardiography, Inferior Myocardial Infarction

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ABSTRACT

Introduction: We aimed to assess the effect of right ventricular myocardial segmental and global function by using conventional two-dimensional echocardiography (2D) and new available echocardiographic techniques including real-time three-dimensional echocardiography (3DE). **Materials/Methods**: Fifty patients with first inferior wall myocardial infarction (Inf MI) were divided into two groups, including 25 with RVMI and 25 without RVMI. Twenty five age matched individuals were included as control. Right ventricular ejection fraction (RVEF) with 3DE, Tricuspid Annular Plane systolic excursion (TAPSE), RV fractional shortening area (FSA), strain (S), strain rate (SR) and systolic tissue velocity (S') of basal and mid segments of RV free wall were measured. **Results**: By 3DE, RVEF was significantly lower in patients with RVMI than those without RVMI and controls (47±6 % vs. 55±5 % and 58±6 %, respectively, P<0.001). There was also remarkably larger RV end systolic volume (RVESV) (44±8 ml vs. 31±6 ml, and 30±7 ml, respectively, P<0.001) and end diastolic volume (RVEDV) (87±8 ml vs. 69±9 ml, and 69±8 ml, respectively, P<0.001) for RVMI group. In the entire population RVEDV and RVESV by 3DE were correlated positively and significantly with the measurements by 2D (r= 0.80, p<0.001; r=0.84, p<0.001, respectively). There was positive significant correlation between 3DE RVEF and FSA (r=0.78, p<0.001), TAPSE (r=0.81, p<0.001), S, SR and S' of basal (r=0.70, p<0.001; r=0.75, p<0.001; r=0.68, p<0.001, respectively) segment of RV free wall. **Conclusion**: RVEF by 3DE was significantly lower in patients with RVMI than those without RVMI and well-correlated with RV FSA, TAPSE, S, SR and S' of basal segment of RV free wall.

INTRODUCTION

In clinical practice, the RV has a great impact on the prognosis of patients with various cardiopulmonary diseases including myocardial infarction involving the RV (1-3). RV infarction has been reported that complicates up to half of the cases of inferior wall myocardial infarction (Inf MI) which leads to higher in-hospital mortality and morbidity (4-9). In spite of this fact that, ST segment elevation in right-sided electrocardiogram leads (v3R and V4R) are sensitive indicators of RV myocardial infarction (RVMI) (4,10,11), they could not predict the magnitude of the RV dysfunction. Echocardiography is the most effective modality for detecting the presence and severity of RV dysfunction (4,7). Several new methods of echocardiography have been introduced for analyzing the RV including myocardial deformational parameters and real-time three-dimensional echocardiography (3DE). The feasibility, reproducibility and accuracy of these novel techniques for assessment of RV function have been recently established (12-18). The aim of this study is to investigate the effect of myocardial infarction on the right ventricular myocardial segmental and global function by using conventional and new available echocardiographic techniques including strain imaging and 3DE.

MATERIALS AND METHODS

Study Population

This study was designed as a cross-sectional and population based study that was conducted from October 2014 to October 2016 in the Heart center hospital in Tehran, Iran. 50 patients with first inferior myocardial infarction were en-

rolled in our study. The control group was another 25 age and gender matched healthy individuals with normal coronary angiography. Patients were divided into two groups: with (25 patients) and without (25 patients) right ventricular myocardial infarction. All of the patients received primary PCI for acute inferior myocardial infarction. Patients with a history of previous ischemic heart disease, heart failure, pericardial disease, pulmonary disease, valvular heart disease, any rhythm other than normal sinus rhythm, bundle branch block, pre excitation, and poor image quality were excluded from our study.

Myocardial infaction (MI) was diagnosed according to existence of typical chest pain,electrocardiographic abnormalities, and diagnostic serial changes in cardiac enzymes . The ECG changes for inferior myocardial infarction was defined as ST segment elevation≥0.1mv in inferior leads (leads II, III, avf). RV infarction was defined as ST segment elevation≥ 0.1 mV in V4R and a culprit lesion proximal to the right ventricular branch of right coronary artery (RCA). Informed consent for enrolment was obtained, and patient anonymity was preserved. The research protocol was approved by the Ethics Committee of Research Center of Tehran Heart Center Hospital, Tehran University of Medical Sciences.

Echocardiography

Echocardiography was performed using a VIVID 7D GE system (General Electrics, Horten, norway). All echocardiographic recordings and analysis were blindly made by an experienced echocardiographer within 48 hours of primary PCI. All recording were performed with a simultaneous ECG. Echocardiographic examination was done in the left lateral decubitus position for each patient.

From the M-mode echocardiographic recordings left ventricular end diastolic and end systolic dimensions and Tricuspid Annular Plane systolic excursion (TAPSE) were obtained. Left ventricular ejection fraction (LVEF) was assessed by modified Simpson's biplane method. RV fractional shorting area (FSA) was calculated from the percentage change between end-diastolic and end-systolic area. Right ventricular diameter was obtained in the four chamber view from the right ventricular lateral wall to the interventricular septum at the mid cavity and end-diastole.

Right ventricular volumetric assessment made by a semiautomated three-dimensional border detection using 4D probe (multiplane modality) by the manual tracing of end-diastolic and end-systolic frames in sagital,4-chamber and coronal views for 3DE images.

Tissue Doppler Imaging (TDI) for longitudinal function was recorded at three levels of RV free wall in the standard apical four-chamber view including basal, mid, and apical segmental levels. All images were obtained a minimum rate of 100 frames per second. Views were stored digitally for offline analysisof regional myocardial systolic tissue velocity (S'), strain rate (SR) and strain (S) curves. The mean of three cycles for V, SR and S were calculated.

Statistical analysis: Data were presented as mean±SD. Analysis of variance (ANOVA) and Bonferroni test for post hoc analysis were used to compare continuous demographic and echocardiographic variables between groups. Correlation between 2DE and 3DE data were obtained using pearson'stest. A p value of less than 0.05 was considered statistically significant.

RESULTS

Subjects' demographic characteristics and hemodynamic data are shown in Table 1. Patients in different groups did not differ in regard to left ventricular ejection fraction (LVEF), LV end systolic diameter (LVSD), LV end diastolic diameter (LVDD), body mass index (BMI) and heart rate(HR). Systolic blood pressure (SBP) was significantly lower in RVMI group (106±10 mmHg vs. 135±13 mmHg and 131±10 mmHg, p<0.001). Right ventricle (RV) diameter was greater in patients with RVMI than the others (35±4 mm vs. 28±2 mm and 29±2 mm, p<0.001). Table 2 shows the mean and standard deviation (SD) of all RV function parameters. Strain (S), strain rate(SR), and systolic tissue velocity (S') of basal (-17±2% vs. -22±4% and -23±3%, p<0.001,-1.5±0.2vs -1.9±0.3 and -2.02±0.2, p<0.001,5.9±1.1 cm/s vs. 9.3±1.5 cm/s and9.4±1.4 cm/s, p<0.001) and mid (-21±3%vs-26±4% and -27±4%, p<0.001,-1.7±0.2 vs. -2.6%±0.3 and -2.2±0.2, p<0.001, 4.6±0.5 cm/s vs. 6.2±1.1 cm/s and 7.8±1.5 cm/s, p<0.001) segments of RV free wall, TAPSE (17±3 mm vs. 22±3 mm and 24±4 mm, p<0.001), and RVFSA (34±5% vs 44±6% and 46±7%, p<0.001) are significantly lower in patients with RVMI as compare to those without RVMI.

Regarding 3DE data of RV global function; RVEF by RT-3DE was decreased significantly in RVMI group in comparison with other groups (47±6% vs. 55±5% and 58±6%, p<0.001). RV end diastolic volume (RVDV) and RV end systolic volume (RVSV) were larger in RVMI group compared to subjects without RVMI (87±8 ml vs. 69±9 ml and 69±8 ml, p<0.001;44±8 ml vs. 31±6 ml and 30±7 ml, p<0.001, respectively).

In the entire population 3D RVDV and RVSV were correlated positively and significantly with 2D RV end diastolic area (RVDA) and RV end systolic area (RVSA), respectively (r= 0.80 , p<0.001; r=0.84, p<0.001, respectively) (Figure 1, 2). There was positive significant correlation between 3DE RVEF and FSA (r=0.78, p<0.001), TAPSE (r=0.81, p<0.001) (Figure 3), S, SR and S′ of basal (r=0.70, p<0.001; r=0.75, p<0.001;r=0.68, p<0.001, respectively) segment of RV free wall.

Figure 4 illustrates the results of ROC analysis for optimal cut off value of 3D RVEF in patients with or without RVMI. 3DE RVEF with cut off value of 52% had a sensitivity of 80% and specificity of 72% for detecting RVMI (p<0.001).

There were no differences between inferior MI without RVMI group and controls regarding TDI, 2D and 3D functional parameters of RV.

DISCUSSION

The results of our study shows that RVEF by 3DE can be used for detecting RVMI in patients with Inf MI. RVEF by 3DE has a good correlation with TAPSE,FSA RV, S, SR and S' of basal of RV.

Although ECG is the most useful and sensitive modality for the diagnosis of RVMI (4,10,11), it is not an indicator of severity of RV dysfunction and its hemodynamic impacts.

Echocardiography is an effective tool for the diagnosis of RV dysfunction and its severity (7). Myocardial tissue systolic velocity, strain and strain rate imaging can assess regional RV function reliably and correctly (1). Strain and strain rate imaging to measure myocardial deformation is less affected by cardiac translational motion and tethering of other organs and are less loaddependent (19).

The new quantitative real-time 3-dimensional transthoracic echocardiography to assess RV volumes and function is relatively simple and feasible (16,20). Furthermore, this method can give more complete and global functional information including base, apex, outflow tract, and free wall of RV in comparison with longitudinal functional parameters such as TAPSE, systolic tissue velocity, and Strain rate imaging (16).

The present study showed that systolic tissue velocity, strain and strain rate were significantly lower in basal and mid segments of RV free wall in patients with RVMI than in patients without RVMI. These results are consistent with the results of study by Serdar Sevimli et al. (21) determined that systolic tissue velocity strain and strain rate were markedly decreased in basal and mid segments in patients with RVMI.

We found that RVDV and RVSV were significantly larger and RVEF was significantly lower in patient with RVMI. 3DE data clearly made difference between patients with RVMI and those without RVMI. These data were supported by a strong positive correlation for RVEF, with 2D and M-Mode echocardiographic parameters of RV including RV FSA, TAPSE and also strain, strain rate, and systolic tissue velocity of the base of RV. These findings are in agreement with the study conducted by Tamborini G.et al. (16). We obtained a cut off value of 52% for RVEF to detect RVMI, that is very close to measures of other studies (16,22,23). A recent published article has introduced RVEF>45% by 3D and global longitudinal strain>20% as normal values for RV (24).

Limitations

A limitation of our study is absence of other 3D techniques such as CMR to compare 3DE data with these techniques however previous studies showed agood correlation between CMR and 3DE data in selected population (22,24,25,26) and 3DE to detect RVMI still needs more validation studies. Another possible limitation of this study is that we did not have RV 3DE software on that time of the study.

CONCLUSION

This study suggests that 3DE parameters of RV volumes and function can be useful in detecting RV dysfunction in patients with RVMI. RVEF by 3DE has a good correlation with TAPSE, RV FSA and tissue velocity and strain rate imaging of base of RV.

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AUTHOR CONTRIBUTION

Hahkimeh Sadeghian : conception and design/ interpretation of data/final approval
Fereshteh Soltani: data gathering /acquisition of data
Masomeh Lotfi Tokaldany: drafting the article/final approval
Arash Jalai: statistical analysis
Afsaneh sadeghian: critical revision

CONFLICT OF INTEREST

There is no conflict of interest.

ETHICAL STANDARDS

Protocol of this study was approved by the ethical committee of Tehran Herat Center.

Table 1: Demographic and hemodynamic data of the study patients

	Controls	IWMI	RVMI	*P* value
Age	56±8	54±5	58±6	NS
Body surface area (m^2)	1.74±0.14	1.72±0.12	1.75±0.12	NS
Systolic blood pressure (mmHg)	131±10	135±13	106±10	<0.001
Heart rate (beat/min)	71±4	70±4	67±5	NS
Right ventricular diameter (mm)	29±2	28±2	35±4	<0.001
Left ventricular ejection fraction (%)	56±4	56±3	55±3	NS
Left ventricular end systolic volume (ml)	33±4	32±3	31±3	NS
Left ventricular end diastolic volume (ml)	49±4	48±5	46±5	NS

IWMI: inferior wall myocardial infarction, RVMI: right ventricular myocardial infarction

Table 2: Demographic and hemodynamic data of the study patients

	Controls	**IWMI**	**RVMI**	**P value**
Basal systolic tissue velocity (cm/s)	9.4±1.4	9.3±1.5	5.9±1.1	<0.001
Mid systolic tissue velocity(cm/s)	7.8±1.6	6.2±1.1	4.6±0.5	<0.001
Apical systolic tissue velocity(cm/s)	2.9±0.3	2.7±0.5	2.7±0.2	NS
Basal strain (%)	-23±3	-22±4	-17±2	<0.001
Mid strain (%)	-27±4	-26±4	-21±3	<0.001
Apical strain (%)	-31±2	-30±3	-29±2	NS
Basal strain rate (s^{-1})	-2.02±0.2	-1.9±0.3	-1.5±0.2	<0.001
Mid strain rate (s^{-1})	-2.2±0.2	-2.06±0.3	-1.7±0.2	<0.001
Apical strain rate (s^{-1})	-2.3±0.2	-2.2±0.3	-2.2±0.2	NS
2-Ddimensional echocardiography				
RV diastolic area	24±3	23±4	30±5	<0.001
RV systolic area	12±4	13±3	20±3	<0.001
RV fractional shortening area	46±7	44±6	36±6	<0.001
TAPSE	24±4	22±3	17±3	<0.001
3-Dimensional echocardiogarphy				
RV diastolic volume (ml)	69±8	69±9	87±8	<0.001
RV systolic volume (ml)	29±7	31±6	44±8	<0.001
RV ejection fraction (%)	58±6	55±5	47±6	<0.001

IWMI: inferior wall myocardial infarction, RVMI: right ventricular myocardial infarction, RV: right ventricle, TAPSE: Tricuspid Annular Plane systolic excursion

Figure legends:
Figure 1: Linear correlation between right ventricular end systolic volume (RVESV) measured by transthoracic 3-dimensional echocardiography and right ventricular end systolic area (RVESA) measured by 2-dimentional echocardiography. (R2=0.855)

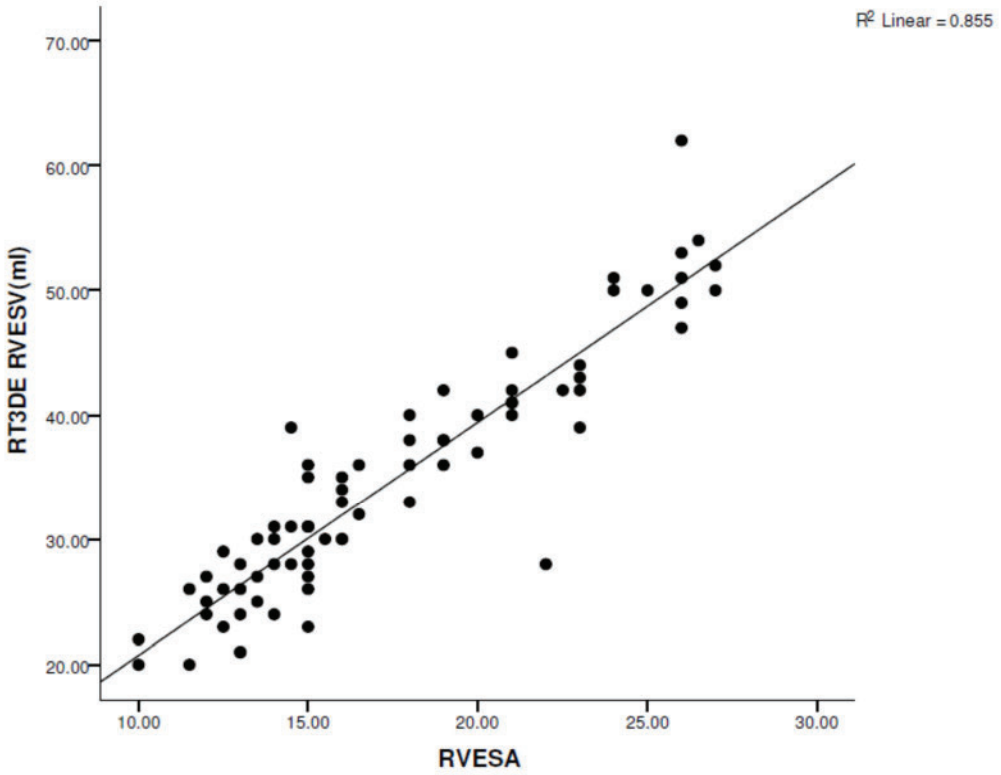


Figure 2: Linear correlation between right ventricular end diastolic volume (RVEDV) measured by transthoracic 3-dimensional echocardiography and right ventricular end diastolic area (RVEDA) measured by 2-dimentional echocardiography. (R2=0.822)

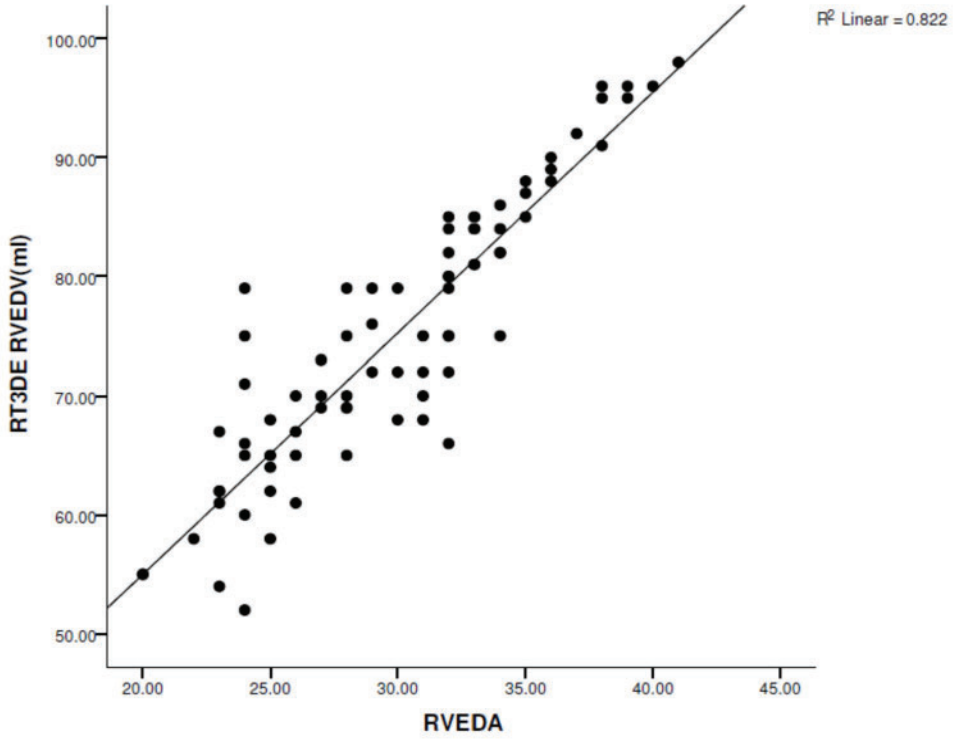


Figure 3: Linear correlation between right ventricular ejection fraction measured by 3-dimensional echocardiography and tricuspid annular plane systolic excursion (TAPSE) measured by 2-dimentional echocardiography. (R2=0.902)

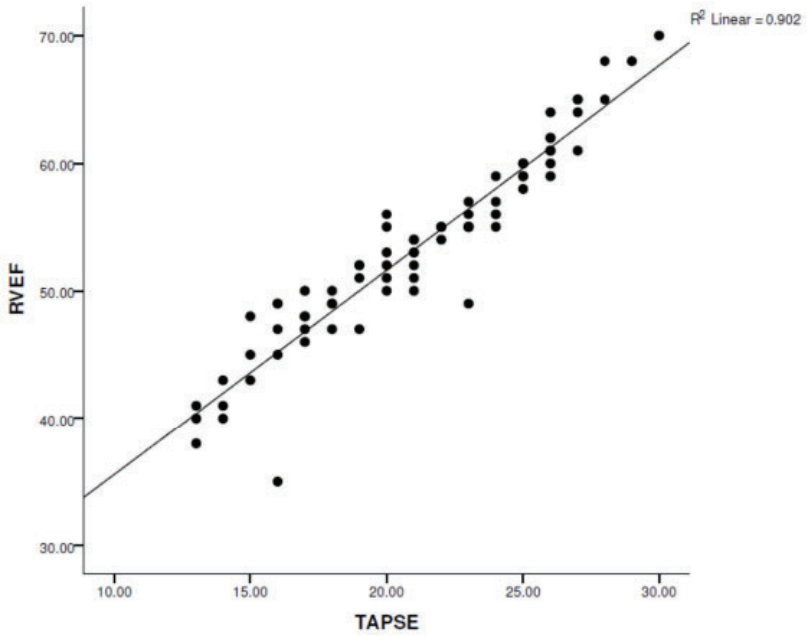
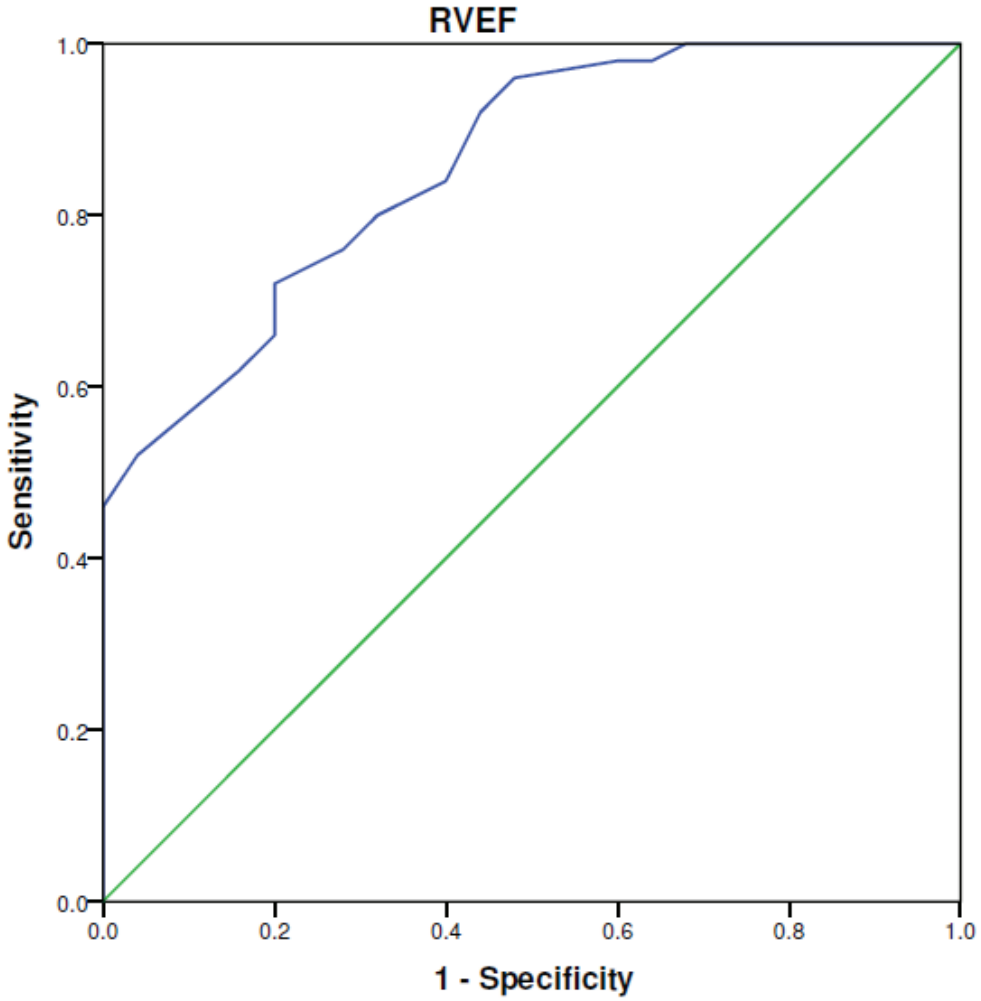


Figure 4: Receiver operating characteristic curve for detecting optimal cut off value of right ventricular ejection fraction (RVEF) measured by 3-dimentional echocardiography to detect patients with right ventricular myocardial infarction. Area under the curve=0.858 (95%CI: 0.773-0.942)



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