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Different Echocardiographic Modalities for Assessment of RV Function in Acute Right Ventricular Myocardial Infarction. A Comparative Study between Thrombolytic Therapy and Primary Percutaneous Coronary Intervention

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ABSTRACT

Background: When compared to cases who had isolated inferior infarctions, those with right ventricular infarctions that occur alongside inferior infarctions had greater odds of bradycardia or severe hypotension, needing pacing support, with higher in-hospital rate of death.

Objective: The aim of the current study to evaluate pulsed wave TDI role together with other Conventional Echo-Doppler modalities in the right ventricular (RV) function assesement among acute inferior ST elevation myocardial infarction (STEMI) associated with RV infarction.

Patients and methods: A two arm, single blinded randomized controlled clinical trial was performed on 100 cases, presenting with acute inferior myocardial infarction (MI) associated with RV infarction, during the period from January 2020 to July 2022. Patients were divided into two groups; ***Group A*** involved 50 cases who underwent coronary angiography and primary percutaneous coronary intervention (PCI), while ***Group B*** involved 50 cases who received thrombolytic therapy.

Results: Patients who had undergone primary PCI showed highly significant improvement of RV systolic function, in comparison with patients who received thrombolytic therapy. In comparison to ***Group B*** (TT), ***Group A*** (PPCI) showed a significant higher S' (14.19±1.77cm/s vs. 10.01±2.66cm/s, P<0.001) and longer ET (285.41±38.83ms vs. 233.82±51.47ms, P<0.001), while isovolumetric times (IVCT and IVRT) were significant lower in ***Group A*** versus ***Group B*** (62.80±13.68ms vs. 79.53±16.26ms, P<0.001; 64.43±19.07ms vs. 80.73±19.20ms, P<0.001, respectively).

Conclusions: Primary PCI is superior to thrombolytic therapy in terms of improvement of RV function where pulsed wave TDI is a more sensitive diagnostic tool of RV infarction.

Keywords: Right Ventricle. Myocardial Infarction, Tissue Doppler Imaging, Thrombolytic Therapy, Primary Percutaneous Coronary Intervention.

INTRODUCTION

Ischemic damage and necrosis of the cardiac muscle characterise acute myocardial infarction (MI), more generally termed as a heart attack. When oxygen and nutrients aren't delivered to cells fast enough, they suffer ischemic damage. We began our publication by discussing the prevalence as well as diagnosing RV infarction, with an emphasis on non-invasive techniques like TDI and other Echo techniques. Later, we attempted to summarise its outlook in light of developments between the eras of fibrinolytic therapy and mechanical reperfusion [1].

Right ventricular functions as well as size can be thoroughly assessed with relative ease and low cost using echocardiography. The RV has a complicated and unusual crescent form, making accurate measurements of its size and function difficult using echocardiographic imaging [1]. As a result, the RV cannot be seen in its whole in a standard 2D echocardiographic image. Therefore, for a comprehensive evaluation of the RV, data from all acoustic windows and echo modalities are required. Furthermore, the clinical report should provide an evaluation using both qualitative and quantitative criteria [2].

The current study objective was to evaluate the role of pulsed wave TDI together with conventional Echo-Doppler modalities in assessing right ventricular function in the setting of acute inferior STEMI associated with RV infarction.

PATIENTS AND METHODS

A two-arm, single blinded randomized controlled clinical trial was performed on 100 cases, presenting with acute inferior myocardial infarction (MI) associated with RV infarction, during the period from January 2020 to July 2022. Patients were recruited from the Cardiology Department of National Heart Institute, Cairo, Egypt.

Inclusion criteria:

Acute de novo inferior ST EMI as documented by:

- Evidence of inferior ST elevation myocardial infarction (STEMI) evidenced by typical chest pain, typical rise of biochemical markers of myocardial necrosis and In the inferior leads of II, III, as well as the AVF, there must be an ST-segment elevation equal to or greater than 1mm.
- Patients with acute myocardial infarction or chest pain showed ST segment elevation in leads V1,

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V3R, and V4R on a right-sided ECG. Lead V4 R ST-segment elevation was the most reliable indicator of right ventricular involvement [2].

- Age group 30-75 years old.

Exclusion Criteria:

1. Pulmonary arterial hypertension, which may impair RV function or exacerbate RV dysfunction.
2. Elevation of the ST segment in leads of the 12-lead electrocardiogram (ECG) other than the inferior leads or the Right Chest leads.
3. The presence of left BBB, Wolff-Parkinson-White (WPW) or any other base ECG changes which might complicate the diagnosis.
4. The presence of ventricular hypertrophy criteria in the ECG, and /or 2-dimensional echo.
5. The presence of any other conditions that may cause ECG changes, e.g. Pericarditis, myocarditis, or electrolyte disturbances.
6. History of Previous MI that would aggravate or worsen the patient condition, regardless of whether or not RV infarction is present.

The **First Group** involved 50 cases had Acute Inferior STEMI associated with RV MI underwent Primary PCI (PPCI), while the **Second Group** involved another 50 cases had Acute Inferior STEMI associated with RV MI and treated with Thrombolytic Therapy (TT). The most up-to-date STEMI treatment guidelines were applied to both groups.

Methods:

History: The patients' diagnoses were written down, and their whole medical histories were recorded. Personal, family and historical background information.

Physical Examination:

General examination.

Vital signs: Temperature, Pulse, Blood pressure and Respiratory Rate.

Anthropmetric measures: Height, weight, and calculation of body mass index.

Systemic examination: In patients with Inferior Wall MI (IWMI), clinically the triad of clear lung fields, hypotension, as well as increased jugular venous pressure has long been thought to predict RV infarction. The specificity of this triad, however, is quite high (96%), but the sensitivity is somewhat poor (25%) [3]. **Kussmaul's** venous sign (jugular venous distension on inspiration), RV infarction can share this symptom with constrictive pericarditis [4].

Laboratory investigations: Routine serum samples for Cardiac Troponin-T, creatine kinase (CK) and creatine kinase-MB isoenzyme (CK-MB), prothrombin time, partial thrombolastin time, blood urea nitrogen (BUN), serum Creatinine, LFTs and blood glucose were investigated after presentation to the Emergency Department.

ECG: At admission, we had an ECG with the usual 12 leads plus right precordial and posterior chest leads. All patients also have serial ECG recordings. Successful reperfusion is defined as greater than a 50% decrease in the ST segment at 90 minutes [5]. High-risk people can be identified in the setting of IW MI by the presence of ST-segment elevation in lead V4 R [6-9]. ST-segment elevation in right precordial leads, notably V4R, is associated with decreased RV EF, which in turn is associated with serious consequences and hospitalization [2]. ST elevation in lead III is more prominent in RVMI than in lead II, while ST depression in lead V2 is more pronounced in RVMI than in lead aVF [10].

Echocardiography: All patients have received an M-mode, 2D, and pulsed Doppler echocardiography. From the supine and left lateral positions, we were able to get an apical four-chamber view, an RV-focused apical four-chamber view, a modified apical four-chamber view, an image of the left parasternal long axis, an image of the left parasternal RV inflow, and an image of the left subcostal space, for the sake of providing photos for a full evaluation of RV dimensions, systolic and diastolic functions, and systolic pressures [11].

Ethical Consideration:

This study was ethically approved by the Institutional Review Board [IRB] of the Faculty of Medicine, Benha University. Also, the protocol and all supporting paperwork were approved by the National Heart Institute's Cardiology Division. Written informed consent was obtained from all participants. This study was executed according to the code of ethics of the World Medical Association (Declaration of Helsinki) for studies on humans.

Statistical analysis:

The collected data were introduced and statistically analyzed by utilizing the Statistical Package for Social Sciences (SPSS) version 20 for windows. Qualitative data were defined as numbers and percentages. Chi-Square test and Fisher's exact test were used for comparison between categorical variables as appropriate. Quantitative data were tested for normality by Kolmogorov-Smirnov test. Normal distribution of variables was described as mean and standard deviation (SD), and independent sample t-test was used for comparison between groups. P value ≤ 0.05 was considered to be statistically significant.

RESULTS

Sociodemographic and clinical charatersitics of all patients in both groups were collected and summarized in Table 1.

Table (1): Sociodemographic and clinical charatersitics of recrutied patients.

Patient Characteristics	Group I	Group II	P-value
	Mean±SD	Mean±SD	
Age (years, mean ± SD)	53.34±2.84	53.25±4.40	0.904
Gender Male Female	 31 (62%) 19 (38%)	 36(72%) 14(28%)	0.288
Diabetes mellitus (n, %)	30 (60%)	26 (52%)	0.420
Hypertension (n, %)	28 (56%)	30 (60%)	0.685
Dyslipidemia (n, %)	32 (64%)	33 (66%)	0.834
Smoking (n, %)	24 (48%)	20 (40%)	0.420
Family history of Coronary artery disease (n, %)	14 (28%)	10 (20%)	0.349
Body mass index (mean ± SD)	28.99±5.26	26.71±6.71	0.062
Heart rate (Beats/min) (mean ± SD)	80±23	89±27	0.081
Diastolic Blood pressure (mmHg) (mean ± SD)	55±15	52.5±22.5	0.520
Systolic Blood pressure (mmHg) (mean ± SD)	87.5±27.5	90±30	0.669
Peak cardiac Troponin T (ug/dL, mean ± SD)	7.78±6.52	8.22±7.27	0.754
Arrhythmias			
Complete Heart Block (n, %)	5 (10%)	**4** (8%)	0.727
Sinus Bradycardia (n, %)	8 (16%)	**6** (12%)	0.564
Premature Ventricular Contractions (n, %)	21 (42%)	**17** (34%)	0.410
Atrial Fibrillation (n, %)	1 (2%)	**2** (4%)	0.558
VT & VF (n, %)	2 (4%)	**1** (2%)	0.558

VF: Ventricular fibrillation, VT: Ventricular tachycardia.

Table 2 summarizes Echocardiography M-mode measurements of the patients.

Table (2): Conventional echocardiography findings (M-mode measurements) in the whole study population.

M-mode measurements	Group I	Group II	P-value
	Mean±SD	Mean±SD	
LVEDD (mm)	53.69±1.61	53.90±2.44	0.617
LVESD (mm)	32.46±1.12	32.41±1.20	0.824
LVPWd (mm)	9.93±0.40	9.92±0.60	0.865
IVSd (mm)	8.92±0.96	8.83±1.15	0.675
LVEF %	46.5±9.5	44±9	0.187
TAPSE (mm)	21.25±4.15	18.25±3.65	<0.001**
MAPSE (mm)	12.6±2.1	12.5±1.8	0.801

IVSd: Interventricular Septal Dimesion at end Diastole, LVEF: Left ventricular ejection fraction, LVESD: Left Ventricular End Systolic Dimesion, LVEDD: Left Ventricular End Diastolic Dimesion, LVPWd: Left Ventricular Posterior Wall Dimesion at end Diastole, SD: Standard Deviation, TAPSE: Tricuspid annular plane systolic excursion. MAPSE: Mitral annular plane systolic excursion

Table 3 summarizes Echocardiography **2D measurements** of the patients.

Table (3): 2D measurements in the form of RV parasternal long axis (PLAX) proximal diameter and RV fractional area change.

2D measurements	Group I	Group II	P-value
	Mean±SD	Mean±SD	
RV PLAX proximal Diameter (mm)	27.09±6.14	31.88±7.01	<0.001**
RV FAC (%)	44.56±7.39	36.91±7.17	<0.001**

PLAX: Parasternal Long Axis, FAC: Fractional Area Change

RV systolic function was significantly enhanced, as measured by peak systolic velocity using TDI of the lateral annulus of the tricuspid valve; S' wave., as indicated by S' wave, that was significantly higher in Group I compared to Group II (**Table 4**).

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Table (4): PW-TDI velocities of the lateral annulus of the tricuspid valve in both groups.

PW TDI parameters	Group I	Group II	P-value
	Mean±SD	Mean±SD	
S' (cm/s) (peak systolic velocity)	14.19±1.77	10.01±2.66	<0.001
E' (cm/s) (peak early diastolic velocity)	14.63±1.81	9.19±1.99	<0.001
A' (cm/s) (peak late diastolic velocity)	12.74±2.33	11.28±1.56	<0.001
IVCT (isovolumetric contraction time) (ms)	62.80±13.68	79.53±16.26	<0.001
IVRT (isovolumetric relaxation time) (ms)	64.43±19.07	80.73±19.20	<0.001
ET (ejection time) (ms)	285.41±38.83	233.82±51.47	<0.001
MPI (myocardial performance index)	0.42±0.09	0.55±0.13	<0.001

PW-TDI: Pulsed wave - tissue Doppler imaging

DISCUSSION

In the current study, statistical analysis showed significantly higher RV FAC in ***Group I*** (PPCI), (44.56±7.39%) compared with ***Group II*** patients (TT) (36.91±7.17%) (P<0.001).

Clinical investigations showed that a higher risk of death and HF was associated with a lower RV function as measured by RVFAC in patients with LV failure following AMI [12-17]. However, RVFAC measurement relies on the observer's prior experience, and its reproducibility is generally subpar. Consequently, RVFAC may not accurately portray contractility [18].

Among our study, Higher significant levels of TAPSE were found in ***Group I*** (PPCI) (21.25±4.15), compared to ***Group II*** (TT) (18.25±3.65) (P<0.001). TAPSE was an independent predictor of mortality in an analysis of 194 AMI patients, even after accounting for LVEF and age [19].

To the best of our knowledge, this is the first work that used TDI to compare the effect of the type of reperfusion therapy (thrombolytic therapy vs primary PCI) on the outcome of RV function.

Among our study, RV systolic function was significantly enhanced, as measured by peak systolic velocity using TDI of the lateral annulus of the tricuspid valve (S' wave, as indicated by S' wave that was significantly higher in ***Group I*** compared to ***Group II***.

A recent clinical investigation demonstrated the ability to distinguish proximal from distal RCA stenosis by measuring S'. S' was substantially lower in individuals with proximal RCA compared to those with distal RCA lesions [14]. This finding agrees with the findings of a previous study, which found a strong correlation between S' and proximal RCA in IWMI patients [20]. This is consistent with the findings of other clinical studies which have found that tricuspid S' can serve as a predictor of RVMI [15], as well as a clinical investigation that demonstrated the best link between tricuspid S' and RV ejection fraction (EF) by cardiac magnetic resonance and tricuspid S' [21]. S' and TAPSE were also found to be useful in assessing RV function in conjunction with IWMI in a separate clinical investigation [22].

One study indicated that RV-S' and multivessel disease were predictors of mortality and readmission rates a year later in patients with inferior MI who underwent diagnostic angiography and TDI measurements within 48 h., and also that a RV- S' <8 cm/s was able to predict RVI [15]. Another clinical trial found that despite 3D echocardiography's use in estimating RVEF, it does not outperform TDE S′ in identifying RVMI. According to the results presented, S′ should replace RVEF as the gold standard for identifying RV infarction in clinical practise because easier to achieve than RVEF, with comparable specificity, ROC area under curve as well as sensitivity [23].

In our study, statistical analysis showed significant improvement of RV systolic function following PPCI, as justified by the statistically significant difference of Myocardial Performance Index (MPI) between both groups, with ***Group II*** (TT) (0.55±0.13) being significantly and abnormally higher than ***Group I*** (PPCI) (0.42±0.09) (P<0.001). **El Sebaie and Khateeb** showed that, RV IVRT was substantially longer and ET was significantly shorter in people with proximal RCA compared to those with distal RCA. This is due to the fact that patients with proximal RCA had a statistically significant increase in the prevalence of RVMI. In addition, those individuals who had proximal RCA had a much greater MPI. This was because IVCT was stretched out while ET was shortened [14].

El Sebaie and Khateeb used multiple regression analysis to determine that mitral annular plane systolic excursion (S') was the strongest independent predictor of proximal RCA lesions (P=0.0001). Proximal RCA could be diagnosed with 95% sensitivity and 97% specificity using an MPI cutoff value of 0.58. Identification of this group of patients at presentation using an MPI cut-off value may aid in the timely assessment and management of RVI [14].

The MPI is able to detect the presence of a proximal RCA lesion and offer a global assessment of RV function by combining data from the systolic as well as diastolic phases of the cardiac cycle [24]. This finding is in agreement with the findings of a previous clinical study, which found that in the hyperacute

phase of MI, MPI of the left ventricle and RV are significantly higher than in control patients [25].

According to **Ozdemir *et al.*,** TDI can be used to identify the RCA-proximal culprit in acute inferior MI if RV-S' is >12 cm/s and RV-MPI is >0.70 [20]. However, research by **Hsiao *et al.*** found that RV-MPI >0.42 is a robust indication of RVI [26]. This disparity is probably due to the fact that patients in the **Ozdemir *et al.*** research did not get coronary intervention until 1 month following recruitment [20]. RV-IVCT and RV IVRT both gave varying degrees of power for assessing RVI, but the lateral tricuspid annular MPI (RV-MPI) was shown to be the most accurate by **Hsiao *et al.*** [26].

However, our study showed different results compared to those of **Hsiao *et al.*** [26], as both RV- S' and RV-MPI were significantly affected with RVI, and both have high significant diagnostic and prognostic importance. Also, other important parameter, was that in our study, ***Group I*** patients have undergone PPCI within 90 minutes of presentation; The patients in the control group of the trial by **Ozdemir *et al.*** did not undergo coronary intervention until 1 month after enrollment, which stands in stark contrast to the treatment group.

The study by **Hsiao *et al.*** has a significant flaw due to the lag time between main PCI and TDI measurements. When it comes to maximising the potential for rapid RVI improvement, TDI is best carried out either alongside primary PCI or soon thereafter. It would be unethical to evaluate TDI simultaneously because it could influence the primary PCI procedure and acute MI is still a life-threatening situation. Echocardiographic image quality might also be greatly impacted by irritability and respiratory distress. As a result, 6 hours is an appropriate time frame for separating primary PCI and TDI readings [26]. This is in accordance with our study.

It is recommended that S′ velocity be measured on the free-wall side of the chamber at <9.5 cm/sec and RV MPI to be more than 0.54 by TDI, based on the recommendations of the ASE and the EACVI [27].

TT and PPCI were examined as RVI patients and the effects of initial RT on early and late mortality: a randomised controlled trial. The infarction extended to the right ventricular walls in 679 (25.3% of the total) of the 2679 consecutive patients admitted between January 1996 and March 2009 with a first acute inferior-posterior left ventricular MI (IPLVMI).

In that clinical trial, PPCI reduced mortality by 44% due to reversal of RVWMA and improvement in perfusion of the RCA and its major branches (TIMI 3 flow: 87%) (69 %), increased CO and mean systolic arterial pressure (mSAP) and decreased ventricular arrhythmias; lowered mRAP, RVEDP, and mean pulmonary wedge pressure (mPWP) [28].

They discovered an ongoing rise in fatality rates beyond the first year in this particular case[29]. The effectiveness of reperfusion therapy likely played the most role in determining the final result [18, 30]. Recent clinical evidence indicates that primary percutaneous coronary intervention (PCI) is superior to thrombolytic therapy and reduces short- and long-term mortality for all RVI categories. Patients with CS should be encouraged to have PPCI rather than TT, as the major reperfusion surgery; consequently, these patients should be sent to a primary coronary intervention hospital in order to lower the high morbidity and mortality of RVI patients who had cardiogenic shock [28].

CONCLUSION

1) TDI was proved to be an accurate, valuable, safe, reliable and relatively inexpensive diagnostic tool of right ventricular infarction and evaluation of right ventricular function.
2) Pulsed wave TDI is a more sensitive method to detect right ventricular ischemia than the subjective evaluation of regional wall motion abnormalities by conventional echocardiography.
3) Successful reperfusion of the culprit artery using Primary PCI is superior to Thrombolytic Therapy (TT), and it leads to better improvement of the RV systolic function than TT.

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- **Competing interests:** Nil.

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