Correlation between right ventricular systolic function with types of myocardial infarction as per site and angiographic finding in patients presenting with first episode of STEMI.

[1]Suchismita Bhuyan*; [2]Chabi Satapathy; [3]Nirmal Mohanty.

[1]Assistant professor, Dept. Of Cardiology, SCB MCH, Cuttack.
[2]Professor, Dept. Of Cardiology, MKCG medical college, Berhampur.
[3]Associate professor, Dept. of Cardiology,SCBMCH, Cuttack.
Corresponding Author: Suchismita Bhuyan

Abstract:

Important clinical implications result from the correlation between RV systolic function and coronary angiography findings. Patients with coronary artery disease (CAD) who are at greater risk of adverse cardiovascular events, such as heart failure or arrhythmias, can be identified using risk stratification. Furthermore, it can provide guidance for treatment decisions regarding revascularization strategies (e.g., coronary artery bypass grafting or percutaneous coronary intervention) and the necessity for supplementary therapies to optimize RV function study aimed at correlating RV systolic function with coronary angiographic findings. **Materials & methods:** After obtaining permission from the Institutional Ethics Committee, the present study was initiated. This study was conducted in the Department of Cardiology, Institute of Cardiovascular Science, S.C.B. Medical College and Hospital, Cuttack. Indoor patients with a diagnosis of Acute STEMI were admitted. The study duration was 18 months between October 2013 and September 2015. A total of 141 patients were included in this study. All patients were diagnosed with Anterior wall myocardial infarction (AWMI) or inferior wall myocardial infarction (IWMI). **Conclusion:** It was concluded that RV systolic function becomes increasingly apparent, and its evaluation is a crucial component of comprehensive cardiac evaluation when CAD is present.

Key words: Coronary artery disease, Myocardial Infarction, Right Ventricular Dysfunction, Anterior wall myocardial infarction (AWMI), inferior wall myocardial infarction (IWMI), Tricuspid Annular Plane Systolic Excursion (TAPSE), Systolic Excursion Velocity of Lateral Tricuspid Annulus (S’).

Introduction:

Globally, cardiovascular diseases continue to be significant contributors to morbidity and mortality, with coronary artery disease (CAD) being particularly prominent. Historically, methods such as coronary angiography have been used to evaluate CAD [1]. This technique is critical in determining the severity and extent of coronary artery stenosis. Nevertheless, with the progression of knowledge regarding cardiac physiology, there has been a growing acknowledgement of the significance of evaluating not only the coronary arteries per se, but also the ramifications of CAD on the right ventricle's (RV) overall functionality [2]. The correlation between coronary angiographic findings and RV systolic function has attracted increasing interest.

Despite being frequently eclipsed by the left ventricle in terms of prominence, the right ventricle serves a critical function in preserving cardiovascular homeostasis [3]. The function of this organ is to transport deoxygenated blood from the venous to pulmonary circulation, thereby ensuring that the blood is adequately oxygenated prior to its distribution throughout the body [4]. As a result, any dysfunction in right ventricular (RV) function can significantly impact the overall performance of the heart and, ultimately, the prognosis and quality of life of the patient [5].

Coronary angiography is a widely recognized diagnostic technique used to visually inspect and evaluate coronary arteries [6]. The procedure involves intravenous administration of a contrast dye into the aforementioned arteries, followed by X-ray imaging, which enables the detection of stenosis or obstruction [1]. Although coronary angiography offers significant insights into the presence and extent of coronary artery disease, its primary purpose is luminal evaluation, with emphasis on the anatomical features of the coronary vessels [2]. Nevertheless, CAD is a multifaceted pathological mechanism that has the potential to affect myocardial perfusion and, as a result, cardiac function, in addition to luminal stenosis [4].

In recent years, RV systolic function has increasingly been acknowledged as a critical factor in patients with CAD. The RV is especially susceptible to variations in coronary blood flow because in the majority of cases, it obtains its blood supply from the right coronary artery [6]. Significant coronary artery disease-induced ischemia can compromise the contractility of the right ventricle (RV) and initiate a series of hemodynamic disruptions such as hypotension, myocardial infarction, and ultimately heart failure [7]. Determining the prognostic and diagnostic significance of RV function evaluation in patients with CAD is of growing importance [8].

RV systolic function can be evaluated using a variety of imaging modalities such as radionuclide imaging, cardiac magnetic resonance imaging (MRI), and echocardiography [9]. These methods facilitate a thorough assessment of RV functionality by revealing RV morphology, contractility, and hemodynamics. By correlating imaging study results with coronary angiography outcomes, medical professionals can acquire a more comprehensive understanding of the cardiac consequences associated with CAD [10].

Important clinical implications result from the correlation between RV systolic function and coronary angiographic findings [6,7]. Patients with CAD who are at a greater risk of adverse cardiovascular events, such as heart failure or arrhythmias, can be identified using risk stratification [3,4]. Furthermore, it can provide guidance for treatment decisions regarding revascularization strategies (e.g., coronary artery bypass grafting or percutaneous coronary intervention) and the necessity for supplementary therapies to optimize the function of the RV [5]. Therefore, the present study aimed to correlate RV systolic function with coronary angiographic findings.

Materials & methods:

After obtaining permission from the Institutional Ethics Committee, the present study was initiated. This study was conducted in the Department of Cardiology, Institute of Cardiovascular Science, S.C.B. Medical College and Hospital, Cuttack. Indoor patients with a diagnosis of Acute STEMI were admitted. The study duration was 18 months between October 2013 and September 2015. A total of 141 patients were included in this study. All patients were diagnosed with Anterior wall myocardial infarction (AWMI) or inferior wall myocardial infarction (IWMI). Inclusion criteria: Patients presenting with a first episode of acute anterior or inferior wall myocardial infarction within 12 hours of symptom onset and admitted to the Cardiology, Institute of Cardiovascular Science, S.C.B. Medical College and Hospital, Cuttack. The criteria for diagnosis of acute ST-elevation myocardial infarction (MI) will be as follows, acute ischemic symptoms lasting more than 30 minutes, and ST elevation at the J-point in two contiguous leads with the cut-off points ≥ 0.1 mV in all leads other than V2 and V3 where the following cut points apply: ≥ 0.2 mV in men ≥ 40 years; ≥ 0.25 mV in men < 40 years, or ≥ 0.15 mV in women. The location of MI was operationally defined as inferior wall MI and isolated ST elevation at the J-point fulfilling the above cut-off points in any 2 leads out of leads II, III,and aVF. Anterior wall MI was defined as ST elevation at the J-point fulfilling the above cut-off points in any two contiguous leads from leads V1-V4 with or without ST elevation in leads V5, V6, I, and aVL. The presence of RVMI in association with inferior with MI was defined by an ST-segment elevation J-point of ≥ 0.1 mV in lead V4R. Informed consent was obtained from all patients prior to inclusion. The exclusion criterion was clinical or electrographic evidence of a previous myocardial infarction. The location of MI that could not be defined by the definitions given above included previously demonstrated abnormal ventricular function, valvular heart diseases, permanent pacemakers of ICDs, left or right bundle branch blocks, congenital heart disease, pulmonary hypertension with RV systolic pressure by ECHO > 40 mmHg, pulmonary embolism, atrial fibrillation, and poor transthoracic echo window.

All two-dimensional, M-mode, and Doppler echocardiographic measurements were performed according to the guidelines of the American Society of Echocardiography using the Siemens Accuson CVO echo machine within 48 h of patient presentation. All measurements were repeated three times, and the mean values were obtained. The following parameters were used to assess RV systolic function: tricuspid annular plane systolic excursion (TAPSE), Systolic Excursion Velocity of Lateral Tricuspid Annulus (S’), MPI by Pulsed Doppler Method (MPI-PD), and Right Ventricular Fraction Area Change(FAC). In our study, we operationally defined right ventricular systolic dysfunction in a patient if two or more of the above-mentioned parameters were abnormal.

Images of the coronary tree of all patients were obtained in routine standardized projections using the digital quantitate Siemens Axiom Artis Zee System (Siemens, Germany). Coronary angiography (with or without PCI) was performed to detect the culprit lesion within 1 week of admission.

Significant lesion/stenosis was defined in the coronary angiogram as the presence of total occlusion, > 70% stenosis, acute thrombosis, or dissected plaque in the coronary artery. Proximal LAD, proximal RCA, and dominant LCX lesions were all defined according to the American Society of Echocardiography.

Group I: Anterior wall MI (n=78). Group I was further subdivided into Group I-A (patients with significant proximal LAD lesions (N =47]). Group II-B (patients with significant mid or distal LAD lesions (without proximal lesions), n=31).

Group II: Inferior wall MI (with or without RVMI, n=63). Further sub-divided into II-A: Patient with significant proximal RCA lesion (n=26), II-B: patient was significant mid or distal RCA lesion (without proximal lesion), n=28,and II-C:patients with significant domiant LCX lesion (n=9).

Statistical analysis:

All continuous variables are presented as mean ± standard deviation (SD), and categorical data are expressed as frequencies and percentages. Comparison of categorical variables between two groups was done by unpaired t-test and between more than two groups was done by one-way ANOVA. The correlation between two echocardiographic variables was determined by linear regression. Statistical significance was set at $P < 0.05$.

Results & Discussion:

Although the clinicopathological syndrome of myocardial infarction has been known for at least a century, dominant right ventricular involvement has been first described in the past 12 years. A study [11] found that the right ventricle was affected in 34% of patients with inferior wall MI. wade described 11 patients with right ventricular infarction all of whom had proximal occlusion of the right coronary artery. This is not surprising since the right ventricular free wall contraction contributes only part, and possibly a small part, of the total systolic volume change of the right ventricle. Contraction of the interventricular septum and crista supraventricularis may be far more important than contraction of the free wall. Since the interventricular septum receives blood from the left anterior descending coronary artery, right ventricular dysfunction might occur not only in patients with inferior infarction, but also in those with anterior infarction.

Transthoracic echocardiography is a widely available, inexpensive, and safe modality for assessing RV function. Although conventional 2D-echocardiographic assessment of right ventricular systolic function is difficult owing to the complex geometrical shape and poor delineation of the endocardial border of the RV, the use of M-mode and Doppler echocardiography may be quite helpful for this purpose.

In this study, we examined right ventricular systolic function in the first episode of inferior and anterior wall MI using four echocardiographic parameters of RV systolic function: 1. tricuspid annular plane systolic excursion (TAPSE), 2. Systolic excursion velocity of the lateral tricuspid annulus (S); 3. MPI using the pulsed-wave Doppler method (MPI-PD); 4. Right: ventricular fractional area change (FAC). We also studied the association of these parameters with the location of significant lesions in infarct-related arteries.

Comparison based on the location of MI: In our study, 141 patients were included, of whom 78 (55.31%) had anterior wall MI according to the ECG criteria (Group I) and 63 patients (44.68%) had inferior wall MI (Group II). This finding was consistent with the study conducted by a study [12], in which 52% of patients with first STEMI had AWMI. 58 of the 42 patients with IWMI, 19 patients fulfilled the ECG criteria for RVMI (ST elevation in lead V4R), that is, 30.15% of IWMI patients had ECG evidence of RVMI. Although it is typically thought that 50% of IWMI is associated with RVMI, various studies [12-14] have shown the occurrence of RVMI in 14 to 84% of IWMI cases. We also observed that the sensitivity of ECG based on the evidence of RVMI (ST elevation in lead V4R) to predict proximal RCA lesions was 76.47%, and the specificity was 100% in our study.

A total of 114 patients (80.78%) were male and 27 (19.22%) were women. Most of the patients were aged 51–60 years (n=47; 33.23%). There were no significant differences in age or sex distribution between groups I and II. Differences in the presence of CAD risk factors of CAD as DM, hypertension, and history of current smoking were also not statistically significant. We found that TAPSE in group II patients were significantly reduced as compared to group I patients (17.06 ± 4.37 mm vs 18.59 ± 2.40; $p=0.02$). S' values were also significantly lower in group II as compared to group I (11.85 ± 3.12 cm/s vs 13.43 ± 2.24 cm/s; $p = 0.01$). These findings are in concordance with the study done by a study [12] where he found that IWMI patients had significantly lower TAPSE (19.1 ± 2.8 mm vs 22.4 ± 2.2; $p<0.05$) and S' (13 ± 2.5 cm/s vs 15.1 ± 1.5 cm/s; $p<0.05$) as compared to AWMI patients.

MPI values were significantly higher in group II than in group I (0.52 ± 0.36 vs 0.38 ± 0.14, $p=0.04$). However, the FAC values were not significantly different between groups I and II. The LVEF in group I patients was significantly lower than that in group II patients ($49.17 \pm 11.59\%$ vs $54.77 \pm 4.98\%$; $p=0.004$). Monika Maheshwari et al [15] found in their study that TAPSE had a significant linear positive correlation with LVEF in patients of AWMI with a correlation coeeficient of 0.76. We also found that TAPSE, S‘, and FAC all showed significant linear positive correlations with LVEF in group I patients, that is, lower values of TAPSE, S, ' and FAC were associated with lower LVEF in AWMI and vice versa. MPI-PD showed a significant negative correlation with LVEF in group I, that is, higher MPI-PD values and lower LVEF in group I, and vice versa.

In group II, TAPSE showed a significant positive correlation and MPI-PD showed a significant negative correlation with LVEF. However, the correlation of S' and FAC with LVEF was not significant in this group. We used the operational definition for the presence of abnormal values of two or more parameters out of the four parameters studied (TAPSE, S', MPI-PD, and FAC), according to the cut-off values provided by the American Society of Echocardiography guidelines. Accordingly, we found that 14 of 78 patients in group I had RV systolic dysfunction and 28 of 63 patients in group II had RV systolic dysfunction. Thus, RV systolic dysfunction was significantly associated with IWMI compared to AWMI ($p = 0.01$).

We found that the LVEF in patients with RV systolic dysfunction was significantly lower than that in patients without RV systolic dysfunction in group I ($31.42 \pm 5.16\%$ vs $53.04 \pm 8.58\%$; $p <0.0001$). Thus, the presence of RV systolic dysfunction significantly correlates with the extent of LV systolic dysfunction in AWMI patients. However, there was no significant difference in LVEF between patients with and without RV systolic dysfunction in Group II (53.72 ± 5.17% vs 55.94 ± 5.16%; p=0.06). Similar results were observed in a study by Caplin et al [16] who measured RV ejection fraction and LV ejection fraction in patients with first STEMI by radionuclide angiography and found that both parameters showed a significant positive correlation with AWMI (r=0.87, p < 0.01). No correlation was observed in the patients with IWMI.

Comparison based on the location of significant lesions in the infarct-related artery

In group I, 47 (60.25%) out of 78 patients had significant proximal LAD lesions (group IA), and 31 (39.74%) patients had significant mid or distal LAD lesions without proximal lesions (group IB).

It was seen that TAPSE were lower in group – IA as compared to group – IB and the difference was highly significant (17.87 ± 2.48 mm vs 19.67 ± 1.83 mm; p = 0.0041). MPI – PD was significantly higher in the IA group than in the IB (0.43 ± 0.14 vs 0.30 ± 0.09, p = 0.04). The FAC was significantly lower in the IA group than in the IB (36.56 ± 6.86% vs 40.50 v 3.47; p = 0.02). However difference in the values of S' was not significant (13.01 ± 2.46 cm/s vs 14.06 ± 1.70 cm/s; p = 0.07).

In group IA, 14 of the 47 patients had RV systolic dysfunction, whereas in group IB, none of the patients had RV systolic dysfunction. Thus, RV systolic dysfunction was significantly associated with proximal LAD lesions (P = 0.01). This may be due to the proximal LAD lesion (p = 0.01). This may be because the proximal lesion will compromise major septal branches as compared to distal lesions, leading to more septal dysfunction. Increased septal dysfunction causes an increase in RV systolic dysfunction because of ventricular interdependence. However, we did not find any previous studies comparing proximal and non-proximal LAD lesions in terms of RV dysfunction.

In Group II (n=63), 26 patients (41.26%) had significant proximal RCA lesions (Group IIA). 28 patients (44.4%) had significant mid-or distal RCA lesions (without proximal lesions) (group IIB). Nine patients (14.2%) had significant LCX lesions (the IIC group). Among the patients in group II, the TAPSE values were significantly lower in group IIA (13.42 ± 2.61 mm) than in groups IIB (18.90 ± 3.64 mm; p < 0.001) and IIC (21.82 ± 1.44 mm; p < 0.001). The S' values were also significantly lower in group IIA (9.40 ± 1.44 cm/s) than in groups IIB (13.03 ± 2.86; p < 0.001) and IIC (15.53 ± 1.20; p <0.001). The MPI – PD values were significantly higher in group IIA (0.80 ± 0.33) than in groups IIB (0.34 ± 0.25; p <0.001) and IIC (0.22 ± 0.04; p <0.001). FAC values were significantly lower in group – IIA (30.53 ± 6.82%) as compared to group – IIB (39.85 ± 6.57%; p < 0.001) and group – IIC (41.00 ± 3.22; p <0.01). Differences in the values of TAPSE, S', MPI – PD, and FAC between groups IIB and IIC were not significant (p >0.05 for each parameter). RV systolic dysfunction was significantly associated with group IIA compared to groups IIB (p = 0.0003) and IIC (p = 0.0022). The differences in LVEF between groups IIA, IIB, and IIC were not significant (p = 0.57).

Kurtulus Ozdemir et al [17] also found similar findings in their study. They compared S' and MPI between proximal RCA lesions, distal RCA lesions, and circumflex artery lesion groups in patients with first acute IWMI. S' and MPI were significantly higher in patients with proximal RCA lesions than in those with distal RCA and circumflex artery lesions.

Rajesh et al. [18] studied the echocardiographic parameters of RV function in patients with IWMI and compared these parameters between proximal and non-proximal RCA lesions. They found that TAPSE, S', MPI, and FAC were significantly lower in patients with proximal artery stenosis than in those without proximal artery stenosis. Our observations were consistent with these findings. However, unlike our study, they found that the LVEF in patients with proximal RCA lesions was significantly lower than that in patients without proximal lesions.

Conclusion:

It was concluded that RV systolic function becomes increasingly apparent, and its evaluation is a crucial component of comprehensive cardiac evaluation when CAD is present. By amalgamating the information obtained from coronary angiography and RV imaging modalities, medical professionals can enhance their comprehension of the intricate relationship between coronary artery disease and RV dysfunction. Acquiring this present study's knowledge has the potential to result in enhanced risk stratification, individualized treatment approaches, and ultimately, better-performing patients. Subsequently, the methodologies employed to evaluate RV systolic function, potential ramifications for patient management, and the most recent research discoveries in this dynamic domain will be examined in the subsequent sections of this study.

Conflict of interest:

The authors declare that they have no conflict of interest.

References:

1. Saeed M, Malahfji M. Medical Management of Aortic Disease: If They Don't Need Surgery, What Do They Need?. Methodist DeBakey Cardiovascular Journal. 2023;19(2):70.
2. Stone PH, Libby P, Boden WE. Fundamental pathobiology of coronary atherosclerosis and clinical implications for chronic ischemic heart disease management—the plaque hypothesis: a narrative review. JAMA cardiology. 2023 Feb 1.
3. Javadzadegan H, Separham A, Farokhi A, Applegate C, Nader ND. The critically low levels of vitamin D predicts the resolution of the ST-segment elevation after the primary percutaneous coronary intervention. Acta Cardiologica. 2023 Jan 2;78(1):40-6.
4. Takenaka S, Sato T, Nagai T, Omote K, Kobayashi Y, Kamiya K, Konishi T, Tada A, Mizuguchi Y, Takahashi Y, Naito S. Impact of right ventricular reserve on exercise capacity and quality of life in patients with left ventricular assist device. American Journal of Physiology-Heart and Circulatory Physiology. 2023 Mar 1;324(3):H355-63.
5. Tun HN, Almaghraby A, Kavalerchyk V, Muraru D, Soliman-Aboumarie H, Abdelnabi M. Acute right ventricular failure: pathophysiology, diagnostic approach with emphasis on the role of echocardiography. Current Cardiology Reviews. 2023 Jul 1;19(4):6-13.
6. Ji M, Zhang L, Gao L, Lin Y, He Q, Xie M, Li Y. Application of Speckle Tracking Echocardiography for Evaluating Ventricular Function after Transcatheter Pulmonary Valve Replacement. Diagnostics. 2023 Dec 30;14(1):88.

7. Hahn RT, Lerakis S, Delgado V, Addetia K, Burkhoff D, Muraru D, Pinney S, Friedberg MK. Multimodality Imaging of Right Heart Function: JACC Scientific Statement. Journal of the American College of Cardiology. 2023 May 16;81(19):1954-73.
8. Moura B, Aimo A, Al-Mohammad A, Keramida K, Ben Gal T, Dorbala S, Todiere G, Cameli M, Barison A, Bayes-Genis A, von Bardeleben RS. Diagnosis and management of patients with left ventricular hypertrophy: Role of multimodality cardiac imaging. A scientific statement of the Heart Failure Association of the European Society of Cardiology. European Journal of Heart Failure. 2023 Sep;25(9):1493-506.
9. Lee S, Husain N, Griffin L, Rigsby CK, Robinson JD. Pediatric Cardiovascular Magnetic Resonance Imaging. InPediatric Cardiology: Fetal, Pediatric, and Adult Congenital Heart Diseases 2023 Sep 14 (pp. 1-48). Cham: Springer International Publishing.
10. Pan J, Ng SM, Neubauer S, Rider OJ. Phenotyping heart failure by cardiac magnetic resonance imaging of cardiac macro-and microscopic structure: state of the art review. European Heart Journal-Cardiovascular Imaging. 2023 Jun 2:jead124.
11. Ratliff NB, Kopelman RI, Goldner RD, Cruz PT, Hackel DB. Formation of myocardial zonal lesions. The American Journal of Pathology. 1975 May;79(2):321.
12. Rashid H. Assessement of Right Ventricular Function in Patients with Acute Myocardial Infarction by Tissue Doppler. HMJ. 2013 Jan;7(1).
13. Mukhaini M, Prashanth P, Abdulrehman S, Zadjali M. Assessment of right ventricular diastolic function by tissue Doppler imaging in patients with acute right ventricular myocardial infarction. Echocardiography. 2010 May;27(5):539-43.
14. Minamishima T, Sakata K, Mizuno Y, Sato K, Takemoto K, Taguchi H, Soga Y, Yoshino H. Usefulness of right ventricular tissue Doppler imaging for diagnosis of right ventricular myocardial infarction. Journal of echocardiography. 2013 Sep;11:89-96.
15. Maheshwari M, Mittal SR. " Simpson's right ventricle ejection fraction versus tricuspid annular plane systolic excursion in patients with isolated left ventricle anterior myocardial infarction". Indian Heart Journal. 2010 Jul 1;62(4):316-9.
16. Caplin JL, Dymond DS, Flatman WD, Spurrell RA. Global and regional right ventricular function after acute myocardial infarction: dependence upon site of left ventricular infarction. British heart journal. 1987 Aug;58(2):101.
17. Özdemir K, Balci S, Duzenli MA, Can I, Yazici M, Aygul N, Altunkeser BB, Altintepe L, Turk S. Effect of preload and heart rate on the Doppler and tissue Doppler-derived myocardial performance index. Clinical Cardiology: An International Indexed and Peer-Reviewed Journal for Advances in the Treatment of Cardiovascular Disease. 2007 Jul;30(7):342-8.
18. Rajesh GN, Thottian JJ, Subramaniam G, Desabandhu V, Sajeev CG, Krishnan MN. Prevalence and prognostic significance of left ventricular myocardial late gadolinium enhancement in severe aortic stenosis. Indian Heart Journal. 2017 Nov 1;69(6):742-50.