Predictors of Complications among Patients with Acute Inferior and Right Myocardial Infarction

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Abstract

Introduction: Early recognition of acute right ventricular myocardial infarction (RVMI) is very crucial for the initiation of treatment to avoid complications. Objective: The objective of this study is to assess the predictors of complications in patients with acute inferior and RVMI. Patients and Methods: This prospective, single-center study included 100 patients with acute inferior and RVMI presented within 6 h of symptoms onset. All patients received streptokinase as thrombolytic therapy. The patients had undergone conventional two-dimensional echocardiography to assess LVEF, RVEF, RVFAC, and tricuspid annular plane systolic excursion (TAPSE), tissue Doppler to assess s’, e’, a’ waves and myocardial performance index (MPI), and speckle tracking echocardiography to assess RV global longitudinal strain. All echocardiographic parameters were done within the first 12 h of admission and 2 months later. Results: Of 100 patients with acute RVMI; 27 patients had complications, the most common complication was atrioventricular block followed by cardiogenic shock. Mortality occurred in only one patient. On comparing the complicated and noncomplicated groups on admission, we revealed that; as regarding the clinical data, the female gender, presence of diabetes, lower systolic and diastolic blood pressure, and lower pulse were independent risk factors for occurrence of complications in RVMI with P < 0.029, 0.009, 0.004, 0.009, and 0.0001, respectively. Of the echo-cardiographic parameters on admission, dilated RV, lateral S, MPI, TAPSE, and speckle were independent predictors for the occurrence of complications in patients with RVI with P < 0.005, <0.0001, 0.0001, 0.0001, and 0.011, respectively. We can use lateral s’, TAPSE, MPI, and speckle with cutoff value 7.9, 13.5, 0.765, −15.9, respectively, for prediction of in-hospital complications in acute RVMI patients (P < 0.0001 for each parameter). Conclusion: Of the echo-cardiographic parameters dilated RV, lateral S, MPI, TAPSE, and speckle were independent predictors for the occurrence of complications in patients with RVMI.

Keywords: Echocardiography, myocardial infarction, thrombolytic therapy

INTRODUCTION

Right ventricular myocardial infarction (RVMI) is associated with higher in-hospital morbidity and mortality compared to that occur in patients with isolated inferior myocardial infarction. Hemodynamic (cardiogenic shock and persistent hypotension) and electrical complications are more common than mechanical complications, and dreadful complication of RV dysfunction is arrhythmias. Long-term prognosis is generally good for those who survive the event.[1]

The diagnosis of RV infarction by physical examination depends on the triad of hypotension, venous distension, and clear lung fields in the setting of an inferior wall myocardial infarction, but it is only 25% sensitive. Jugular venous pressure (JVP) elevation >8 cm and a Kussmaul’s sign predicts RVMI with greater sensitivity but less specificity. ECG is also less sensitive for the diagnosis of RV infarction. ST-segment elevation 0.1 mV in lead V4R had sensitivity of 83% in diagnosing RVMI and specificity 77%.[3]

Echocardiographic analysis of the RV involvement can shed light on the severity of the disease and help to assess the RV function high-risk groups for aggressive management like

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RV function was assessed using the following methods: RV EF was assessed using the biplane Simpson’s method,[7] lateral RV wall motion abnormality was assessed using right ventricular FAC (RVFAC), the apical four-chamber view was utilized, RVFAC was calculated through the following formula: (end-diastolic area × end-systolic area)/end diastolic area × end-systolic area.[8] Tricuspid annular plane systolic excursion (TAPSE) was measured as the total displacement of tricuspid annulus from end-diastole to end-systole,[4] tissue Doppler imaging study was done to peak systolic, peak early and late diastolic velocities of tricuspid annulus (S’, E’ and A’, respectively) from the lateral tricuspid annulus, MPI or Tei index (using the pulsed tissue Doppler method) is calculated using the following formula: MPI = (IVRT + IVCT)/ET,[9] RV global longitudinal strain (GLS): Apical four-chamber view was utilized. The images were recorded with a frame rate of ≥50 frames/s to allow for the reliable operation of the software. Images were stored in cine loop format from 3 consecutive beats, and transferred to a workstation for further offline analysis. Myocardial strain can be calculated by measuring the change of the position of the speckles within a myocardial segment during the cardiac cycle.[10] Coronary angiography: All patients underwent diagnostic coronary angiography after thrombolytic therapy.

**Methods of data analysis and statistical evaluation**

Data were collected and entered into the computer using the SPSS (Statistical Package for the Social Science) program for the statistical analysis version 18 (SPSS Inc, Chicago, IL, USA). Quantitative data were shown as a mean ± standard deviation Qualitative data were expressed as frequency and percent. Chi-square test was used to measure association between qualitative variables. Mann–Whitney test (z) and independent-sample t-test were done to measure the association between two sets of quantitative data. Multivariate regression analysis was performed to detect the independent variables. The results of comparing the correlation between two continuous variables were indicated by the correlation coefficient (r) using correlation analysis. The clinical performance the ECHO parameters in predicting complications was assessed by the receiver operating characteristic (ROC) curves. Sensitivity, specificity, positive predictive value , and negative predictive value were presented as percentages. P (probability) value considered to be of statistical significance if it is <0.05.[11]

**Results**

The study sample consisted of 100 patients with acute inferior and RVMI. The baseline general characteristics of the study population are shown in Table 1.

**Table 1: Baseline general characteristics of study population (n=100)**

| Sex, n (%) | Male | Female |
|------------|------|--------|
| 62 (62.0) | 38 (38.0) |

| Age (years), mean±SD (minimum-maximum) | 59±7.9 (42-73) |
|----------------------------------------|-----------------|
| Hypertension, n (%) | 42 (42.0) |
| Diabetes, n (%) | 50 (50.0) |
| Hyperlipidemia, n (%) | 77 (77.0) |
| Smoking, n (%) | 56 (56.0) |
| Family history, n (%) | 7 (7) |
| SBP, mean±SD (minimum-maximum) | 95.8±10.6 (80-120) |
| DBP, mean±SD (minimum-maximum) | 57.8±6.2 (40-70) |
| Heart rate, mean±SD (minimum-maximum) | 56.3±7.98 (40.0-78.0) |
| SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SD: Standard deviation |

The study aimed to assess the predictors of complications in patients with acute inferior and right myocardial infarction.

**Conventional echocardiography**

Global LV function was assessed using the biplane Simpson’s method.[7] RV function was assessed using the following measurement: RV EF was assessed using the biplane Simpson’s method,[7] lateral RV wall motion abnormality was assessed using right ventricular FAC (RVFAC), the apical four-chamber view was utilized, RVFAC was calculated through the following formula: (end-diastolic area × end-systolic area)/end diastolic area × end-systolic area,[8] tricuspid annular plane systolic excursion (TAPSE) was measured as the total displacement of the tricuspid annulus from end-diastole to end-systole,[4] tissue Doppler imaging...
population are listed in Table 1. Complications were found in 27% of cases, the most common complication was AVB (13% of cases), followed by cardiogenic shock (8% of cases). AF occurred in 5% of cases. The death occurred in only 1% of cases. The mean age was significantly higher in the complicated group. Female gender and the presence of diabetes were more prevalent in the complicated group. While hypertension, hyperlipidemia and family history were comparable in both groups [Table 2].

On assessing the echo parameters in the complicated and noncomplicated groups; RV dilatation was present in 88.9% of complicated cases in comparison to 41.1% of noncomplicated cases, the lateral RV free wall SWMA were present in 100% of complicated cases, in comparison to 83.6% in noncomplicated cases. Coming to other indices of echo parameters of the RV function; TAPSE, S', FAC, RVEF, speckle tracking, and lateral early e' diastolic velocity were significantly lower in the complicated group than the noncomplicated, whereas the MPI were significantly higher in complicated patients compared with patients without complications [Table 2].

Multivariate regression analysis was performed to assess the independent predictors of complications; of the baseline characteristics; female gender, presence of diabetes, lower systolic and diastolic blood pressure and lower pulse were independent predictors for the occurrence of complications in RVMI. Of the previously assessed echo parameters dilated RV, lateral S, MPI, TAPSE, and speckle were independent predictors for the occurrence of complications in RVMI [Table 3].

The diagnostic performance of the echo parameters in differentiating the complicated from noncomplicated group was assessed using the ROC curve. Mean lateral S' lower than 7.9 can predict the occurrence of complications with sensitivity of 92.6%, specificity of 93.9%, and an accuracy of 93.3%. TAPSE lower than 13.5 can predict the occurrence of complications with sensitivity of 92.6%, specificity of 97.3%, and an accuracy of 95%. MPI more than 0.675 can predict occurrence of complications with sensitivity of 100%, specificity of 98.6%, and an accuracy of 99.3%, and speckle < − 15.9 can predict the occurrence of complications with sensitivity of 88.9%, specificity of 83.6%, and an accuracy of 86.8% [Table 4 and Figure 1].

On follow-up, the echo parameters in both the complicated and non-complicated groups; although all patients improved on follow-up, the improvement was significantly lower in the complicated group than the noncomplicated group [Table 5].

**Table 2: Comparison of the base line demographic characteristics and echo parameters in the complicated and non-complicated patients**

|                          | Complicated (n=27) | Not complicated (n=73) | P     |
|--------------------------|-------------------|------------------------|-------|
| Sex, n (%)               |                   |                        |       |
| Male                     | 9 (33.3)          | 53 (72.6)              | <0.0001|
| Female                   | 18 (66.7)         | 20 (27.4)              |       |
| Age, mean±SD             | 64.5±7.75         | 57.0±7.7               | <0.0001|
| Hypertension, n (%)      | 12 (44.4)         | 30 (41.1)              | 0.763 |
| Diabetes, n (%)          | 21 (77.8)         | 29 (39.7)              | 0.001 |
| Hyperlipidemia, n (%)    | 23 (85.2)         | 54 (74.0)              | 0.237 |
| Smoking, n (%)           | 15 (55)           | 41 (56)                | 0.7   |
| Family history, n (%)    | 2 (7.4)           | 5 (6.8)                | 0.923 |
| SBP, mean±SD             | 85.9±8.55         | 99.4±8.84              | <0.0001|
| DBP, mean±SD             | 52.0±6.08         | 59.3±4.75              | <0.0001|
| Puls, mean±SD            | 47.9±6.11         | 59.47±6.14             | <0.0001|
| RV dilatation, n (%)     | 24 (88.9)         | 30 (41.1)              | 0.0001|
| SWMA, n (%)              | 27 (100.0)        | 61 (83.6)              | 0.025 |
| TAPSE (mm), mean±SD      | 12.37±0.8         | 15.29±1.02             | <0.0001|
| Lateral S (cm/s), mean±SD| 7.17±0.58         | 8.89±0.57              | <0.0001|
| Lateral E (cm/s), mean±SD| 7.51±1.07         | 8.36±1.26              | 0.002 |
| Lateral A (cm/s), mean±SD| 9.49±1.45         | 9.62±1.47              | 0.679 |
| MPI, mean±SD             | 0.75±0.03         | 0.55±0.04              | <0.0001|
| FAC (%), mean±SD          | 24.8±2.756        | 30.64±2.621            | <0.0001|
| RVEF, mean±SD            | 40.00±5.575       | 48.48±4.049            | <0.0001|
| Speckle, mean±SD         | −13.7±1.81        | −16.3±1.06             | <0.0001|

SD: Standard deviation, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, RV: Right ventricular, E: Early diastolic annular velocity, A: Late diastolic annular velocity, TAPSE: Tricuspid annular plan systolic excursion, MPI: Myocardial performance index, FAC: Fractional area change, RVEF: RV ejection fraction, SWMA: Systolic wall motion abnormalities

**Table 3: Multivariate regression analysis for the predictors of complicated myocardial infarction**

|                | B    | SE   | Exp (B) | 95% CI          | P    |
|----------------|------|------|---------|-----------------|------|
| Sex            | −1.538 | 0.703 | 0.215  | 0.05-0.76       | 0.029 |
| Diabetes       | 1.548 | 0.596 | 4.702  | 1.36-13.5       | 0.009 |
| Smoking        | 0.422 | 0.754 | 1.525  | 0.37-6.96       | 0.576 |
| Age            | −0.051 | 0.051 | 0.950  | 0.858-1.051     | 0.283 |
| SBP            | −1.419 | 0.971 | 1.730  | 0.826-1.092     | 0.004 |
| BP             | 0.237 | 0.108 | 1.268  | 1.025-1.567     | 0.009 |
| Puls           | 0.314 | 0.093 | 1.369  | 1.142-1.642     | <0.0001|
| Dilated RV     | 4.472 | 1.579 | 17.5   | 3.4-19.3        | 0.005 |
| SWMA           | 19.262 | 11591 | 0.655  | 0.248-2.95      | 0.999 |
| TAPSE          | 1.174 | 0.282 | 3.173  | 2.55-8.19       | <0.0001|
| Lateral S'      | 0.253 | 0.059 | 5.224  | 3.72-11.54      | <0.0001|
| Lateral E'     | 0.030 | 0.052 | 0.439  | 0.56-3.13       | 0.563 |
| MPI            | −4.360 | 0.302 | 9.31   | 1.95-6.44       | <0.0001|
| FAC            | −0.008 | 0.011 | 0.997  | 0.50-17.7       | 0.011 |
| RVEF           | −0.007 | 0.007 | 0.518  | 0.14-1.72       | 0.293 |
| Speckle        | −0.041 | 0.016 | 0.506  | 0.13-0.67       | 0.011 |

SE: Standard error, CI: Confidence interval, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, RV: Right ventricular, TAPSE: Tricuspid annular plan systolic excursion, S': Systolic annular velocity, MPI: Myocardial performance index, FAC: Fractional area change, RVEF: RV ejection fraction, SWMA: Systolic wall motion abnormalities

**Discussion**

Concomitant RVMI with inferior MI may initially present without evidence of hemodynamic compromise characteristic of RVMI, but subsequently develops hypotension precipitated by preload reduction attributable to nitroglycerine or associated
Early recognition of acute RVI is very crucial in initiation of treatment for hypotension and shock and to avoid therapy that will lower right heart preload (nitrates and diuretics). [12]

This prospective, single-center study included 100 patients with acute inferior and right myocardial infarction presented within 6 h of symptoms onset. All patients received thrombolytic therapy. The commonest complication in present study was A VB, followed by cardiogenic shock and AF. Death occurred in only one case. Ravikeerthy and Yogi, reported that the incidence of AF was 4%, AV block was present in 24%, cardiogenic shock occurred in 10% and death occurred in 15% of RVMI patients. [14]

On trying to assess the incriminated risk factors for the occurrence of complications, the mean age was significantly higher in the complicated group than the noncomplicated group. Female gender and the presence of diabetes were more prevalent in the complicated group both are independent predictors for occurrence of complicated RVMI. Concomitant with our results Jim et al., concluded that advanced age, female gender were independent predictors for poor in-hospital outcomes in patients with inferior wall with RVMI. [15] In addition, Roifman et al. reported that the presence of DM conferred an approximately threefold greater odds of being associated with RVD post-RVMI. [16]

Concerning the vital signs in our study as predictors of complications; lower SBP, DBP and the pulse were significant independent predictors for the occurrence of complicated RVMI.

Echocardiography is a noninvasive and useful method that simultaneously provides the diagnosis of RVMI and assessment of cardiac function on the basis of RV wall motion abnormality, RV dilation, and decreased RVEF. [17] However, in patients with mild RVMI with slight hemodynamic abnormalities, RV wall motion abnormality and dilation do not appear; consequently, it is difficult to diagnose RVMI. [18]

In the present study, the mean of the TAPSE was found to be significantly lower in the complicated group (12.37 ± 0.8 mm) than the noncomplicated (15.29 ± 1.02 mm). The preferred method to evaluate RV systolic function is often TAPSE, which is known to correlate with RVEF. [19] TAPSE >15 mm is reported to substantially decrease mortality rates. [20]

In the present study, mean MPI was found to be significantly higher in the complicated group (0.75 ± 0.03) than the noncomplicated (0.55 ± 0.04). MPI may be used for the assessment of global heart function. It enables evaluation

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**Table 4: The performance of the echo parameters in differentiating the complicated from non-complicated group**

| Echo parameter | AUROC | P       | Cutoff  | Sensitivity | Specificity | Accuracy |
|----------------|-------|---------|---------|-------------|-------------|----------|
| S              | 0.972 | <0.0001 | <7.9   | 92.6%       | 93.9%       | 93.3%    |
| TAPSE          | 0.976 | <0.0001 | <13.5  | 92.6%       | 97.3%       | 95%      |
| MPI            | 0.993 | <0.0001 | >0.675 | 100%        | 98.6%       | 99.3%    |
| Speckle        | 0.920 | <0.0001 | >15.9  | 88.9%       | 83.6%       | 86.8%    |

**Table 5: The echo parameters follow up of both complicated and non-complicated groups**

|                     | Complicated n=26 | Not complicated n=73 | P     |
|---------------------|------------------|----------------------|-------|
| dilated2            | 2 (7.7%)         | 0 (0.0%)             | 0.017 |
| SWMA2               | 12 (46.2%)       | 29 (39.7%)           | 0.027 |
| TAPSE2 Mean±SD      | 18.4±0.22        | 21.1±0.18            | <0.0001 |
| S2 Mean±SD         | 9.94±1.57        | 11.8±1.99            | <0.0001 |
| E2 Mean±SD             | 8.91±1.94        | 10.04±1.54           | 0.004 |
| A2 Mean±SD             | 10.77±2.82        | 11.6±2.18            | 0.105 |
| MPI2 Mean±SD               | 0.53±0.05        | 0.48±0.03            | <0.0001 |
| FAC2 Mean±SD                | 33.4±3.3         | 37.18±3.132          | <0.0001 |
| RVEF2 Mean±SD            | 51.65±4.05       | 54.59±3.64           | 0.001 |
| Speckle Mean±SD            | -18.3±2.39       | -21.29±1.43          | <0.0001 |
of both systolic and diastolic function. Reduced ventricular systolic function shortens the ejection time, leading to increased MPI. MPI >0.4 with pulse Doppler and MPI >0.55 with tissue Doppler are considered direct indicators of impaired RV function.[9]

In the present study, tissue Doppler velocities S’ (8.43 ± 0.95 cm/s), S’ was significantly lower in the complicated group (7.170 ± 0.58 cm/s) than the non-complicated (8.896 ± 0.57 cm/s). RV-S’ is a very reliable and easily measured parameter in young adults. TVS’ is considered to be an index for the contractility of the entire right ventricle because TVS’ had a significant correlation with RVEF in radionuclide angiography.[21] It can be measured from the tricuspid lateral annulus by means of tissue Doppler. RV-S’ <10 cm/s is associated with RV systolic dysfunction.[22]

In the present study, mean FAC was found to be significantly lower in the complicated group (24.48% ±3.75%) versus noncomplicated (30.64% ±2.62%). RV-FAC is one of the parameters recommended for the assessment of systolic function. However, this technique is dependent on imaging and the operator’s skill. The normal values of RV-FAC are accepted as >35%.[9] RVFAC has been found to have a good correlation with MRI derived RVEF and is also found to have prognostic significance in patients with myocardial infarction.[23]

In the present study, mean RVGLS was found to be significantly higher in complicated patients compared with patients without complications (–13.7 ± 1.81 vs. –16.3 ± 1.06), (two dimensional) speckle tracking echocardiography (STE) is commonly used because of its accuracy, feasibility, and reliability.[24] Park et al. showed that RV GLS <–15.5% showed significantly lower 5-year survival rate and lower major adverse cardiac events-free survival rate in patients with inferior STEMI.[25]

In the present study, mean RVEF was (46.19% ±5.8%). It was significantly lower in complicated group than noncomplicated group (40.00% ±5.575%) versus (48.48% ±4.049%), respectively. Concomitant with our study Kidawa et al., they studied 85 patients with acute RVMI and concluded that RVEF, 51% allowed the diagnosis of RVMI with sensitivity 91% and specificity 80%.[26]

In the present study, the mean diastolic tissue Doppler e’ velocity was (8.13 ± 1.26). e’ velocity was significantly lower in the complicated group than non-complicated group (7.511 ± 1.07) versus (8.366 ± 1.26), respectively. Reduced early diastolic tricuspid annular velocities have been demonstrated in patients with RV infarction complicating inferior MI.[27]

In the present study, RV dilatation was present in 54% of the case at baseline. It was significantly higher in complicated cases 88.9%, in comparison to 41.1% in non-complicated cases. Come in agreement with our study, Mattioli et al. study showed that in 108 patients with RVMI patients before thrombolysis, all patients had an increase in the RV end-diastolic diameter.[28]

In the present study, lateral RV free wall SWMA was present in 88% of cases. It was significantly higher in complicated cases 100%, in comparison to 61% of noncomplicated cases, respectively. Concomitant with our study, Rajesh et al. showed that RV wall motion abnormalities were detected in 73% of patients with RVMI and correlated with proximal RCA stenosis.[29]

In the present study, as regards the performance of the echo parameters in prediction of the complications dilated RV, lateral S, MPI, TAPSE, and speckle were independent predictors for the occurrence of complicated RVMI. In our study, S lower than 7.9 can predict the occurrence of complications with the sensitivity of 92.6%, specificity of 93.9%, and an accuracy of 93.3.

TAPSE lower than 13.5 mm can predict the occurrence of complications with sensitivity of 92.6%, specificity of 97.3%, and an accuracy of 93.3% and an accuracy of 95%. MPI more than 0.675 can predict occurrence of complications with sensitivity of 100%, specificity of 98.6%, and an accuracy of 99.3%.

Speckle more than –15.9 can predict occurrence of complications with the sensitivity of 88.9%, specificity of 83.6%, and an accuracy of 86.8%.

On comparing the echo parameters at baseline and 2 months post thrombolytic therapy in our study; there was significant improvement in RV function as assessed by echo parameters (TAPSE, S’, FAC, RVEF, speckle tracking, and lateral early diastolic e’, significantly increased and the MPI significantly decreased. The incidence of RV dilatation significantly decreased and the presence of SWMA also significantly decreased.

This comes in agreement with Bayata et al. 2011 when compared 13 patients with RVMI and 18 patients with isolated inferior MI before and after thrombolytic therapy concluded that in patients with RVMI the TAPSE value and systolic tricuspid annular velocity s’ increased significantly after thrombolysis compared with prethrombolysis measurements.[30]

In the present study, there is a positive correlation between echo parameters before and after thrombolytic therapy. Although all patient improved after thrombolytic therapy, the improvement was significantly lower in the complicated group than the noncomplicated group (TAPSE, S’, FAC, RVEF, lateral e’ significantly less increased and the MPI significantly less decreased) also the presence of RV dilatation, SWMA were significantly higher in patients with in-hospital complications post thrombolytic).

The novelty in the present study is determining a cutoff value to predict complications in RVMI patients using lateral s’, TAPSE, speckle, and MPI for aggressive management like primary PCI.

The main limitation of the present study was the small number of patients and that echocardiographic assessment should ideally be performed before thrombolytic therapy as there is
a possibility of recovery of RV function, but it was considered unethical to delay reperfusion for echocardiographic assessment.

**Conclusion**
Of the echocardiographic parameters dilated RV, lateral S, MPI, TAPSE, and speckle were independent predictors for the occurrence of complications in patients with RVMI. We can use lateral s', TAPSE, speckle with cutoff value lower than 7.9, 13.5, –15.9 respectively and MPI with cutoff value higher than 0.765 for prediction of in-hospital complications in acute RVMI patients.

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**Conflicts of interest**
There are no conflicts of interest.

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