Original Research Article

The diagnostic and prognostic value of right ventricle systolic and diastolic function in inferior myocardial infarction patients

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ABSTRACT

Background: Inferior myocardial infarction (MI) with right ventricular (RV) involvement will increase mortality and morbidity. Data of systolic and diastolic RV function in inferior ST-segment elevation MI (STEMI) are useful to predict the RV involvement.

Aims: To evaluate the prognostic and diagnostic significance of RV systolic and diastolic function compared to RVMI diagnostic criteria by electrocardiography in inferior MI patients.

Methods: Consecutive patients with first, acute, inferior STEMI were prospectively assessed. The RVMI was defined as an ST-segment elevation ≥ 0.1 mV in lead V4R. Echocardiography was performed within 24 hours of the inferior STEMI symptoms. We assessed the RVMI diagnostic criteria in inferior MI patients using echocardiography.

Results: Out of 31 patients (mean age 56.39 ± 9.02 years), RVMI by electrocardiography and echocardiography was found in 18 (37%). Moreover, multivariate analysis showed that two variables — RV systolic and diastolic function, were independent predictors of RVMI in inferior MI patients. Sensitivity and specificity of the RV systolic function were 94.4% and 69.2%, respectively, while RV diastolic functions were 44% and 76.9%, respectively.

Conclusion: RV systolic function predict RVMI with relatively high sensitivity and specificity. RV diastolic function predicts RVMI with relatively low sensitivity but with high specificity.

INTRODUCTION

Right ventricular (RV) myocardial infarction (MI) occurs in 30–50% of patients with inferior myocardial MI [1]. It is caused mainly by significant stenosis at proximal right coronary artery (RCA) [2]. The RVMI could lead to RV dysfunction that increases mortality and morbidity in inferior MI patients [3]. Early assessment of RV function in inferior MI patients has great importance, as it provides prognostic information measure and allows proper modification of therapy. The RVMI diagnosis remains a challenge since there is no gold standard ready to use in an emergency clinical setting. Echocardiography allows morphological, hemodynamic, and functional assessment of the RV; however, this modality has limited value because of the asymmetric, pyramidal shape of the RV and nonconcentric contraction which resulted with difficulty for geometric assumptions [4].

Some echocardiographic measurements include cavity size, regional contractility, tricuspid annular

plane systolic excursion (TAPSE), and RV myocardial performance index (RVMPI) [5]. Previous study of the usefulness of pulsed wave TDI in the diagnosis of RVMI in patients with inferior MI was available, however, there are conflicting data on the value of RV myocardial velocities derived from TDI in this group of patients [6]. This study was aimed to evaluate the prognostic and diagnostic significance of RV systolic and diastolic function compared to RVMI diagnostic criteria by electrocardiography in inferior MI patients.

METHODS

This study was an analytical observational study, designed and conducted prospectively. Consecutive 31 inferior MI patients with first, acute, inferior STEMI were undergone examination with echocardiography. Echocardiography examinations performed within 24 hours after the onset of inferior MI were eligible in this study. The diagnosis of inferior STEMI was based on the European Society of Cardiology (ESC) criteria: chest pain lasting > 30 minutes; characteristic ST-segment elevation of less than 0.1mV in two or more inferior derivation (leads II, III, aVF) on ECG, and an increase in biomarkers: troponin I or creatine kinase (CK)-MB. Patients with a history of coronary artery disease, severe valvular diseases, pulmonary embolism, pulmonary hypertension, chronic obstructive pulmonary disease, atrial fibrillation, or poor quality echocardiographic imaging were excluded. All patients gave their written consent. This study was approved by the Hospital ethics committee. All patients with RVMI ECG criteria were assessed with echocardiography and were checked for their RV systolic and diastolic function to finally can be diagnosed as RVMI.

Electrocardiogram

Standard 12-lead ECG and right chest ECG used for RVMI diagnosis were performed immediately at the Emergency Department. The RVMI was defined as an ST-segment elevation ≥ 0.1 mV in lead V4R according to ESC recommendations [7]. All ECGs were assessed by an independent cardiologist, combined with clinical and echocardiographic data.

Echocardiography and tissue Doppler imaging

Echocardiographic examinations were performed within 24 hours of the onset of inferior MI in all patients. Echocardiographic examinations were performed using Vivid I with phased-array 1.8–3.6 MHz transducer, equipped with TDI technology. Cardiologists were asked to examine the clinical presentation and ECG parameters blindly. All measurements were performed according to the recommendations of the American Society of Echocardiograph. Measurements of RV and right atrium diameters, inferior vena cava diameter during respiration, fractional area change of RV, and RV wall motion abnormalities were included in the standard echocardiographic examination. We followed a modified Simpson's rule and Teicholtz measurement when calculated the left ventricular ejection fraction (LVEF).

Statistical analysis

Descriptive statistics were used to describe the mean and standard deviation (SD) for continuous variables and frequency tables for categorical variables. Variables were compared using T-test, ANOVA, Kruskal-Wallis non-parametrical ANOVA, chi-square test, Fisher exact test, or Mann-Whitney test where appropriate. A logistic regression analysis was used to evaluate the predictive value of selected clinical presentation and echocardiographic parameter factors for the presence of ECG changes specifically for RVMI diagnosis. The included factors were age, systolic blood pressure, diastolic blood pressure, and echocardiographic parameters including RV function parameters (RV EF, mitral propagation, fractional area change of RV, and TAPSE) and TDI parameters (SmRV, RV myocardial performance index, EmRV). The model used in the analysis was pre-specified based on the current knowledge of RV dysfunction.

The diagnostic value of parameters in RVMI diagnosis was evaluated by calculating a receiver operating characteristics (ROC) curve. Multivariate logistic regression analysis was carried out to assess the prognostic significance of RV myocardial velocities on the occurrence of the combined end-point in patients with inferior STEMI. The included factors were SmRV, EmRV, age, the extent of MI expressed as peak troponin I, LVEF, ST-segment elevation ≥ 0.1 mV in lead V4R. Events which occurred following echocardiography with TDI were enrolled in the analysis of prognosis. Analysis was carried out using SPSS 20.

RESULTS

This study consisted of 31 consecutive patients. Mean age for this study was 56.39 ± 9.02 years with first, acute inferior STEMI enrolled between 1 November

2014 and 31 December 2014. Out of 18 patients (37%), first STEMI was observed within 24 h of the onset of symptoms and with RV localization. All patients had to fulfil criteria for the diagnosis of type I MI according to the universal MI definition [8]. Exclusive criteria including permanent atrial fibrillation, severe aortic valve disease, severe chronic obstructive pulmonary disease, bundle branch block, poor quality of echocardiographic examination result, and lack of sufficient medical documentation. The patients' characteristics of the study as listed in the

Table 1. Multivariate analysis showed that two variables — RV systolic and diastolic function, were independent predictors of in-hospital prognosis (Table 2). Sensitivity and specificity of RV systolic function to diagnose RV MI in inferior MI were 94.4% and 69.2%, respectively. While sensitivity and specificity of RV diastolic function to diagnose RV MI in inferior MI were 44% and 76.9%, respectively (Figure 1).

Table 1. Patients' characteristics

Variables	RV MI (+)	RV MI (-)	Mean of MI	*p* value
Age	55.89 ± 9.19	57.08 ± 9.09	56.39 ± 9.02	0.03
Systolic Blood Pressure	129.05 ± 28.73	119.15 ± 24.48	130.22 ± 30.57	0.08
Diastolic Blood Pressure	78.33 ± 20.82	73.23 ± 13.72	80.39 ± 21.18	0.08
TAPSE	1.87 ± 0.58	2.00 ± 0.53	1.92 ± 0.56	0.02
S	0.11 ± 0.33	0.13 ± 0.31	0.12 ± 0.20	0.03
FAC RV	51.27 ± 13.3	52.53 ± 19.6	51.80 ± 15.95	0.12
TDI MPI	475.77 ± 18.22	486.56 ± 18.61	480.26 ± 184.12	0.002
E/A RV	1.08 ± 0.46	1.24 ± 0.45	1.15 ± 0.5	0.001
EF RV	44.33 ± 8.51	58.76 ± 6.3	50.38 ± 10.47	0.001
Mitral Propagation	57.02 ± 5.1	58.01 ± 5.05	53.04 ± 42.02	0.01
S/D	1.14 ± 0.51	1.16 ± 0.46	1.15 ± 0.70	0.15

RV, Right Ventricle; TAPSE, Tricuspid Annular Plane Systolic Excursion; FAC RV, Fractional Area Change RV; TDI MPI, Tissue Doppler Imaging (TDI)-derived Myocardial Performance Index (MPI); EF RV, Ejection Fraction RV; E/A, Ratio of E (early diastolic) and A (late diastolic) velocities; S/D, ratio of pulmonary venous waveforms include peak systolic (S) velocity and peak anterograde diastolic (D) velocity.
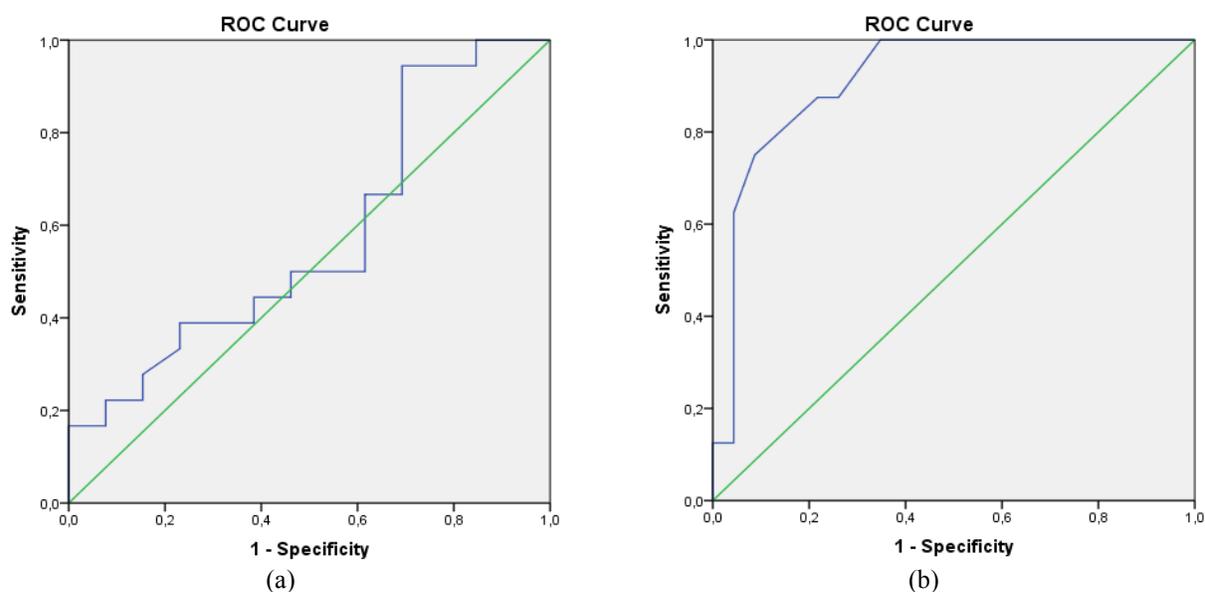

Figure 1. Receiver Operating Characteristics (ROC) curve of diastolic (a) and systolic function (b). Diagonal segments are produced by ties.

Table 2. Multivariate analysis

Variables	Odds ratio	*p* value
EF RV	3,3 (2,5-4,1)	0,004
E/A RV	2,13 (1,8-2,53)	0,005

DISCUSSION

The high value of RV systolic and diastolic function in the diagnosis of acute RVMI in patients with inferior STEMI was orchestrated. In RVMI echocardiographic examination, the measurement of stroke volume is played by the shortening of longitudinal fibers [8]. Meluzin et al. highlighted a peak systolic velocity of tricuspid annulus correlates with RVEF. This measurement was confirmed by MRI [9]. Ueti et al. also found that there was a high correlation between RV systolic velocity and RVEF. The examination was assessed by radionuclide ventriculography [10]. Right ventricular ischemia or infarction will lead to impairment of diastolic function. In diastolic dysfunction, there will be a decrease of compliance and reduced filling of RV in echocardiographic examination [1].

Echocardiography is the most widely available, semi-quantitative RV assessment modality for RV measurement, however, this examination was limited by the complex morphology of the RV and may be further challenged if there was a poor acoustic windows [3]. TDI could overcome the technical challenge with non-geometric indices of RV function. The reproducibility of measurements of RV myocardial velocities was high in this work, and this has also been found by other authors [11]. It was recommended to keep high reproducibility in the acute phase of MI for echo examinations in acute coronary syndrome settings [12]. The results show the pulse wave TDI allowed simple, rapid and quantitative measurements.

In this recent study, RV systolic and diastolic functions were found to be independent predictors of RV MI in inferior MI patients. Meluzin et al. found that patients with systolic velocity of tricuspid annulus < 10.8 cm/s and with symptomatic advanced heart failure exhibited significantly worse event-free survival [13]. RVMI leads to increased early mortality and morbidity in patients with inferior STEMI [3].

We realized that this work lacks of the gold standard for the diagnosis of RVMI suitable for the early phase of hospitalization in intensive cardiovascular care units. Another limitation of this study was we didn't randomize the sample, and we didn't carry out this study in multicenter. We followed the ECG definition of RVMI by ESC [7], however it is limited to the specificity and high dependence of a delay from the onset of symptoms during examination. The issue was disappeared after 24 hours performance on all diagnostic procedures.

CONCLUSION

RV systolic function predicts the diagnosis of RVMI with relatively high sensitivity and specificity. RV diastolic function predicts a diagnosis of RVMI with relatively low sensitivity but with high specificity

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CONFLICT OF INTERESTS

There is no conflict of interests. Nothing to disclosure.

REFERENCES

1. Goldstein J. Pathophysiology and management of right heart ischemia. Journal of American College Cardiology, 2002; 40: 841–853.
2. Bowers TR, O'Neill WW, Pica M, et al. Patterns of the coronary compromise resulting in acute right ventricular ischemic dysfunction. Circulation, 2002; 106: 1104–1109.
3. Kukla P, Dudek D, Rakowski T, et al. Inferior wall myocardial infarction with or without right ventricular involvement — treatment and in-hospital course. Kardiologia Polska, 2006; 64: 583–588.
4. Rudski LG, Wyman WL, Afilalo J, et al. Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: a report from the American Society of Echocardiography Endorsed by the European Association of Echocardiography and the Canadian Society of Echocardiography. Journal of the American Society of Echocardiography. 2010; 23: 685–713.
5. Piestrzeniewicz K, Łuczak K, Piechowiak M, et al. The value of Doppler-derived myocardial performance index and tricuspid annular motion in the evaluation of right ventricular function in patients

with acute inferior myocardial infarction. Folia Cardiolica. 2006; 13: 369–378.

6. Hsiao SH, Chiou KR, Huang WC et al. Right ventricular infarction and tissue Doppler imaging: insights from acute inferior myocardial infarction after primary coronary intervention. Circulation. 2010; 74: 2173–2180.

7. Van de Werf F, Ardissino D, Betriu A, et al. Management of acute myocardial infarction in patients presenting with ST-segment elevation. The Task Force on the Management of Acute Myocardial Infarction of the European Society of Cardiology. European Heart Journal, 2003; 24: 28–66.

8. Thygesen K and Alpert JS. White HD; on behalf of the Joint ESC/ACCF/WHF Task Force for the Redefinition of Myocardial Infarction: Universal definition of myocardial infarction. European Heart Journal, 2007; 28: 2525–2538.

9. Kukulski T, Hübbert L, Arnold M, et al. Normal regional right ventricular function and its change with age: a Doppler Myocardial Imaging study. Journal of the American Society of Echocardiography, 2000; 13: 194–204.

10. Meluzin J, Spinarova L, Bakala J, et al. Pulsed Doppler tissue imaging of the velocity of tricuspid annular systolic motion. A new, rapid, and non-invasive method of evaluating right ventricular systolic function. European Heart Journal, 2001; 22: 340–348.

11. Ueti OM, Camargo EE, Ueti Ade A, et al. Assessment of right ventricular function with Doppler echocardiographic indices derived from tricuspid annular motion: comparison with radionuclide angiography. Heart, 2002; 88: 244–248.

12. Meluzin J, Spinarova L, Hude P, et al. Prognostic importance of various echocardiographic right ventricular functional parameters in patients with symptomatic heart failure. Journal of the American Society of Echocardiography, 2005; 18: 435–444.

13. Meluzín J, Spinarová L, Dusek L, et al. Prognostic importance of the right ventricular function assessed by Doppler tissue imaging. European Journal of Echocardiography, 2003; 4: 262–271.