



The pulmonary annular motion velocity assessed using tissue Doppler imaging could predict the proximal right coronary artery occlusion in patients with inferior myocardial infarction

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Abstract

Objective: The right ventricle myocardial infarction (RVMI) is one of the leading reasons for right ventricle(RV) dysfunction. RVMI occurs in 20-50% of inferior infarctions. Echocardiography was applied to study RV involvement and proximal right coronary artery (RCA) occlusion in individuals with acute inferior MI. The objective of this study was to investigate if pulmonary annulus motion velocity (PAMVUT) levels in individuals with acute inferior myocardial infarction were linked to proximal RCA lesions.

Method: The study comprised 50 people who had been diagnosed with acute inferior myocardial infarction and had culprit lesions in the right coronary artery. The RCA occlusion in Group A was proximal to the right ventricular branch, while the RCA occlusion in Group B was distant to the RV branch. The PAMVUT was tested, as well as other echocardiographic parameters.

Results: In terms of metrics indicating right ventricular function, there were substantial disparities between the groups. A favorable association was established in the univariate correlation analysis between PAMVUT and RV TAPSE, with FAC, and with St.PAMVUT was identified as an independent predictor of proximal RCA occlusion in a multivariate logistic regression test. In the ROC analysis, PAMVUT<8,5 cm/s indicated proximal RCA occlusion with 85 percent sensitivity and 69 percent specificity (AUC=0.80, p<0.001).

Conclusion: PAMVUT measurements were revealed to be an important predictor of proximal RCA occlusions in this investigation.

Keywords: Doppler echocardiography; Inferior myocard infarction; Pulsed-wave tissue Doppler; Right coronary artery; Right ventricular function

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Doku Doppler görüntüleme kullanılarak değerlendirilen pulmoner anüler hareket hızı, inferior miyokard enfarktüsü olan hastalarda proksimal sağ koroner arter tıkanıklığını öngördürebilir

Öz

Amaç: Sağ ventrikül miyokard enfarktüsü (RVMI), sağ ventrikül (RV) işlev bozukluğunun önde gelen nedenlerinden biridir. RVMI, inferior enfarktüslerin %20-50'sinde görülür. Akut inferiyor MI hastalarında sağ ventrikül katılımını ve proksimal sağ koroner arter (RCA) tıkanıklığını tahmin etmek için ekokardiyografi yapıldı. Bu çalışma, RCA'nın suçlunun damarı olduğu akut inferiyor miyokard enfarktüslü hastalarda doku Doppler görüntüleme (PAMVUT) değerleri kullanılarak değerlendirilen pulmoner anulus hareket hızının proksimal RCA lezyonları ile korele olup olmadığını yanıtlamaya çalıştı.

Yöntemler: Sunulan çalışmada, suçlu lezyonları sağ koroner arterde olan akut inferiyor miyokard enfarktüsü tanısı alan toplam 50 hasta alındı. Sağ ventrikül dalı proksimalinde RCA tıkanıklığı olan hastalar Grup A'ya, RV dalının distalinde RCA tıkanıklığı olanlar Grup B'ye atandı. PAMVUT dahil olmak üzere ekokardiyografik parametreler ölçüldü.

Sonuçlar: Sağ ventrikül fonksiyonlarını gösteren parametreler açısından gruplar arasında anlamlı fark vardı. Tek değişkenli korelasyon analizinde; PAMVUT ile RV TAPSE arasında FAC ile St ile pozitif korelasyon bulundu. Çok değişkenli lojistik regresyon testinde PAMVUT proksimal RCA oklüzyonu için bağımsız bir prediktif parametre olarak tanımlandı. ROC analizinde, PAMVUT <8,5 cm/s, proksimal RCA oklüzyonunu %85 duyarlılık ve %69 özgüllükle öngördü (AUC = 0.80, p < 0.001).

Sonuç: Bu çalışmada, PAMVUT değerlerinin proksimal RCA oklüzyonlarının önemli bir belirleyicisi olduğunu bulduk.

Anahtar kelimeler: Doppler ekokardiyografi; inferiyor miyokard enfarktüsü; pulsed-wave doku Doppler; sağ koroner arter; sağ ventrikül fonksiyonu

INTRODUCTION

The right ventricle myocardial infarction (RVMI) is one of the leading reasons for right ventricle(RV) dysfunction. According to studies, almost half of all individuals with an inferior infarct had right ventricular involvement¹. Patients with an inferior infarction and right ventricular involvement had a greater risk of bradycardia, severe hypotension, and mortality than those without². RVMI is most commonly associated with proximal occlusion of a dominant right coronary artery in individuals with inferior myocardial infarction³. Electrocardiograms(EKGs) frequently demonstrate the truth of insufficient to anticipate proximal RCA stenosis being an infarct-related artery⁴. Moreover, EKG alterations are temporary and vanish in nearly half of the cases within ten h, making it less reliable⁵. Echocardiography is the most used modality in daily life to determine RV anatomy and functions; This is due to factors such as

being relatively inexpensive, having no side effects due to its non-invasive nature, and being widely available in almost all cardiology clinics. In individuals with acute inferior myocardial infarction, echocardiographic tests have been used to predict proximal RCA involvement and RV involvement⁶⁻¹⁰.

While evaluating RV functions, mainly parameters based on the longitudinal activities of the RV were taken into account. TAPSE (tricuspid annular plane systolic excursion), tissue Doppler evaluation of tricuspid annular tissue velocity and RV free wall longitudinal strain measured from the apical four chambers are the most often utilized metrics¹¹. The anatomical structure of the RV cannot be evaluated as uniform; of course, the evaluation of RV functions also includes differences. The anatomical appearance of the RV is viewed as a triangle or pyramid. Therefore, the measured

tricuspid annulus-based parameters mean that we measure only from one corner of this triangle. Furthermore, the ventricular function may not be equal and similar in all areas and have varying features depending on the site, direction, and disease character. Accordingly, these methods are not unquestionably suitable for functional assessment. In this context, investigations show that right ventricle outflow tract (RVOT) systolic movements, an essential part of RV functions, are critical¹²⁻¹⁵. A study shows that systolic excursion (RVOT-SE) values measured from RVOT can predict whether the responsible vessel occlusion is in the proximal RCA in acute inferior MI cases¹². Papers demonstrate that another important way revealing RVOT functions is tissue Doppler imaging (TDI) velocities determined from the region where the pulmonary annulus joints with the free RV wall, pulmonary annulus motion velocity assessed using TDI(PAMVUT)¹³⁻¹⁵. We attempted to demonstrate how effective the PAMVUT values recorded in this study are in predicting the site of the RCA occlusion in acute inferior MI patients.

METHODS

The study was planned as a single-center, non-randomized observational study. Ninety-four patients referred to us for revascularization with primary percutaneous coronary intervention for acute inferior myocardial infarction were examined between August 2020 and April 2021. The research covered all of the patients in sequential order. Twenty-four individuals were excluded because of culprit lesions in the circumflex artery (CX); 3 patients were excluded because of left anterior descending artery (LAD) obstruction; due to low image quality, 14 patients were ruled out; and three patients were excluded because of other exclusion factors. Following the exclusion of the instances, 50 patients were left who satisfied the criteria listed: above the age of 18,

within 12 hours after the beginning of symptoms, ST-segment elevation of at least 1 mm in the inferior leads of the ECG, and coronary angiography revealed RCA occlusion. Patients with cardiogenic shock or hemodynamic instability, significant arrhythmias like atrial fibrillation, atrioventricular block, or ventricular arrhythmias, concomitant moderate to severe valvular pathology, active infection, failures of the liver and kidneys, a severe pulmonary illness, or persons who have a history of pulmonary hypertension were not included in the research. Stenosis of more than 50% in the LAD and CX arteries, a history of PCI and MI, and CX dominance in the coronary artery system were all ruled out. Patients with poor echogenicity were also excluded. According to the guideline, patients received appropriate treatment immediately after diagnosing the inferior MI, then revascularized with PCI [16]. RCA obstruction proximal to the RV branch was seen in Group A patients, whereas an RCA occlusion distal to the RV branch was seen in Group B patients.

Using the Vivid 7 machine (GE Vingmed Ultrasound AS, Horten, Norway), all echocardiographic tests were performed within 24 hours of PCI. At the end of the exhalation phase, three cardiac cycles were recorded. All data was sent to a workstation for additional analysis off-line (EchoPAC PC; GE Vingmed Ultrasound AS). Traditional echocardiographic tests in two dimensions (2D) were carried out following the procedures outlined in an American Society of Echocardiography document¹⁷. The left atrium (LA) and ventricle (LV) were both assessed in size. The bi-plane Simpsons technique was used to calculate the LV ejection fraction (EF) [18]. The RV's fractional area change (FAC) was measured with % area change of the RV at end-systole and end-diastole in the apical four-chamber view. TAPSE was calculated by estimating the systolic

displacement of the longitudinally crossing the tricuspid annular plane and parallel to the right ventricle's lateral wall with M mode. Ventricular filling velocities in the early (E) and late (A) waves were obtained by utilizing pulsed-wave Doppler imaging of the mitral inflow profile, and the E/A ratio was computed¹⁹. The systolic (Sm), early diastolic (em), and late diastolic (am) velocities of the myocardium were all assessed by utilizing a TDI sample volume positioned at the septal and lateral mitral annuli. After then, the E/e ratio was established. The St, et, and velocities were also measured using the TDI method by placing a sample volume on the right ventricle's free wall. TDI was used to calculate RV MPI from the lateral tricuspid annulus. The ejection time (ET) was assumed as the duration of Sm. The duration between the end of the Sm and the start of the Em was designated as the isovolumetric relaxation time (IVRT). The isovolumetric contraction time (IVCT) was defined as the period between the commencement of Am and Sm. By dividing the ratio of isovolumetric times by ET, the MPI was determined $[(IVRT + IVCT)/ET]$ ¹¹. In the RVOT's long-axis image, the velocity of the pulmonary annular movement was calculated employing TDI. A sample volume was set with a predetermined length of 5.0mm on the free wall side of the RV's pulmonary annulus. If RVOT's long-axis view is inadequate, a modified parasternal long-axis view was used for PAMVUT.

The local institutional ethics committee approved the investigation (Bolu Abant İzzet Baysal University Faculty of Medicine Ethics Committee, Ethics Committee Acceptance Number: 2021/130 and Date of Acceptance: 25/05/2021). Verbal and written informed consent forms were gathered from all participants.

The percentages, mean, median (25th-75th percentile), and standard deviation represent all of the data. The Kolmogorov-Smirnov test

was used to determine if each variable had a normal distribution. Nonparametric tests were used to compare groups of non-normally distributed data. The continuous variables were compared using the Mann-Whitney U test or the Students t-test. Chi-square and Fisher's exact tests were used to examine the distributions of categorical variables. The correlation between the continuous variables was compared using Pearson's correlation analysis. For the multivariate analysis, significant parameters from the univariate analysis ($p < 0.05$) were chosen. To find independent factors of proximal RCA occlusion, we used multiple logistic regression analyses. The diagnostic effectiveness of each parameter was then investigated using receiver operator characteristic (ROC) curves. The most suitable cut-off values for detecting proximal RCA occlusion were determined. A p-value of less than 0.05 was considered statistically significant. SPSS v16.0 was used for all statistical analyses (SPSS, Inc., Chicago, IL).

RESULTS

Fifty patients were involved in the research. In Group A, twenty-six individuals had an RCA occlusion proximal to the right ventricular branch. An RCA occlusion distal to the right ventricular branch was seen in Group B, which included 24 individuals. Men were more likely to have inferior STEMI in both groups (80.7 percent in group A vs. 83.3 percent in group B, $P = 0.412$); Diabetes mellitus, dyslipidemia, hypertension, smoking, primary PCI, troponin, systolic blood pressure, and heart rate, on the other hand, showed no significant differences between the two groups. Table 1 summarized the clinical, demographic, and laboratory findings of the patients. No statistically significant differences were found across the groups in terms of EDD, ESD, LAD, and EF. There was no significant difference between the groups when the left ventricular diastole measures were compared. However, when we

looked at the metrics that showed right ventricular function, we discovered substantial disparities. Group A had lower TAPSE, St, FAC, and PAMVUT values than Group B (Table 2). In the univariate correlation study, a positive association was established between PAMVUT and RV TAPSE ($r=0.421$, $p=0.001$), with FAC ($r=0.341$, $p<0.001$), and with St ($r=0.259$, $p=0.001$) (Table 3). TAPSE, St, FAC, and PAMVUT were assessed using multivariate logistic regression analysis after showing statistical significance in univariate studies. In a multivariate logistic regression test, the PAMVUT (OR0.541, 95 percent CI0.311–0.768, $p<0.001$) was identified as an independent predictive predictor for proximal RCA occlusion (OR0.541, 95 percent CI0.311–0.768, $p<0.001$) (Table 4). In the ROC analysis, PAMVUT 8,5 cm/s predicted proximal RCA occlusion with 85 percent sensitivity and 69 percent specificity (AUC=0.80, $p<0.001$) (Fig. 1).

Table I: Clinical characteristics, demographic and laboratory finding of the study population.

Variables	Group A(n:26, 52%)	Group B(n:24, 48%)	P value
Sex male(n, %)	18(80.7%)	20(83.3%)	0,412
Age(mean±SD)	57.9±10.6	58.1±11.4	0,542
HT(n, %)	9(34.6%)	9(37.5%)	0,309
DM(n, %)	16(61.5%)	13(54.1%)	0,219
Smoking(n, %)	9(34.6%)	7(29.1%)	0,268
Dyslipidemia(n, %)	12(46.1%)	10(41.6%)	0,387
BMI(kg/m ²)	25.9±4.2	26.3±4.3	0,426
Glucose(mg/dl)	147(100-182)	149(100-195)	0,981
Creatinine(mg/dl)	0.84±0.21	0.85±0.25	0,621
Hemoglobin(mg/dl)	13.5±1.4	13.5±1.5	0,854
Troponin(ng/ml)	2.8(0.3-9.8)	2.0(0.5-7.2)	0,713
Systolic blood pressure(mmHg)	137.8±25.3	135.6±24.8	0,654
Heart rate(bpm)	83.6±13.5	77.9±15.2	0,247
Door to reperfusion(min)	30(30-30)	30(30-30)	0,255

BMI, body mass index; DM, diabetes mellitus; HTN, hypertension

Table II: Echocardiographic characteristic of the study population.

Variables	Group A (n=26)	Group B (n=24)	P value
EDD(cm)	4.8(4.6-5.1)	4.8(4.7-5.2)	0,625
ESD(cm)	3.0(2.8-3.3)	3.1(2.9-3.2)	0,245
LAD(cm)	3.6±0.2	3.7±0,2	0,842
EF(%)	56(50-58)	55(51-58)	0,568
LV E/A	0.8(0.6-0.9)	0.7(0.6-0.8)	0,861
LV E/Em	8(7-9)	8(7-9)	0,596
TAPSE(cm)	1.6±0.3	1.9±0.3	<0,001
St(cm/s)	10(8-12)	13(9-14)	<0,001
RV MPI	0.5(0.4-0.6)	0.5(0.4-0.7)	0,233
FAC(%)	32(28-44)	44(40-47)	<0,001
PAMVUT(cm/s)	8(7-10)	13(8-14)	<0,001

EDD, end diastolic diameter; ESD, end systolic diameter; LAD left atrium diameter, EF, ejection fraction; LV, left ventricle; E, early ventricular filling velocity; A, late ventricular filling velocity; Em ventricular tissue doppler early diastolic velocity, RV right ventricle, TAPSE tricuspid annular plane systolic excursion; PAMVUT, pulmonary annular motion velocity using tissue Doppler imaging; St, tissue Doppler imaging derived tricuspid annulus systolic velocity; MPI myocardial performance index, FAC fractional area change

Table III: Correlation of RV free wall strain with echocardiographic measurements.

Variables	r	p
TAPSE(cm)	0,421	0,001
FAC(%)	0,341	<0,001
St	0,259	0,001

FAC, fractional area change; PAMVUT, pulmonary annular motion velocity using tissue Doppler imaging; St, tissue Doppler imaging derived tricuspid annulus systolic velocity; TAPSE, tricuspid annular plane systolic excursion

Table IV: The result of multivariate logistic regression analysis for the prediction of proximal RCA lesion.

Variable	OR	CI	p
PAMVUT(cm/s)	0,541	0,311-0,768	<0,001

PAMVUT, pulmonary annular motion velocity using tissue Doppler imaging; RCA, right coronary artery

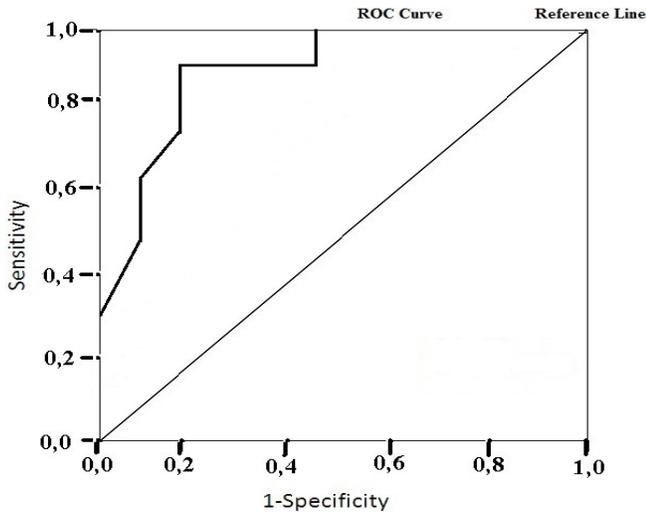


Figure 1: Receiver operating characteristic curve for the prediction of the proximal RCA stenosis. RCA, right coronary artery

DISCUSSION

The PAMVUT value was found to predict the proximal RCA lesion in patients with inferior MI in the present investigation.

Determination of RV functions is of great importance in diagnosing and shaping treatment and prognosis evaluation in many diseases. However, the assessment of these functions carries difficulties in proportion to their preference. The most crucial challenge factor comes from the anatomy of the RV, which is a complex three-dimensional (3D) anatomy and morphology. This situation can be elaborated by giving many examples of these limitations¹¹. FAC could not inevitably express the EF of the whole RV.

TAPSE and St measure simply the longitudinal movement of the lateral RV wall. The sine qua non-rule for 3D echocardiographic evaluations is to select the RV endocardial borders²⁰⁻²². Despite their limitations, previous studies aimed to get an idea about global RV functions, especially by evaluating parameters such as TAPSE, St, and FAC. Furthermore, the ventricular function may not be equal and similar in all RV areas and have varying features depending on the site and disease character.

There are echocardiographic markers in the literature that predict proximal RCA lesions in inferior MI. TAPSE was shown to be lower in individuals with RVMI than those without RVMI in research by Bayata et al.⁸. However, it should be kept in mind that TAPSE has limitations such as reflecting RV free wall longitudinal systole activity, potential to be affected by LV functions, and false high elevation in case of moderate-to-severe tricuspid regurgitation²³. Ozdemir et al. found that the peak $St < 12$ cm/s had a sensitivity of 81 percent and a specificity of 82 percent in diagnosing RVMI and 63 and 88 percent in identifying the proximal RCA as the infarct-related artery in a study of 60 patients with inferior MI⁷. Another research found that $St < 8$ cm/s has a sensitivity of 78% and a specificity of 86% for detecting RVMI in individuals with inferior MI (n = 50). St also shows the longitudinal function of the RV-free wall. Reduced right ventricular free wall strain as a predictor of proximal RCA occlusion in individuals with acute inferior MI by Gecmen et al.²⁵. Strain imaging software may not be available in every echocardiography device. Also, it needs an experienced echocardiographer who knows strain adequately. That can bring out severe restrictions in the utilization. Furthermore, there is currently no specialized program for right ventricular strain imaging; the left ventricle strain imaging program is applied to the right ventricle. FAC also has limitations such as clearly defining the endocardial borders in its calculation, its nature that ignores RVOT functions, and its moderate inter-observer reproducibility²⁶. PAMVUT is a relatively novel parameter for the RVOT function, an essential contributor to RV functions. In patients with surgically corrected CHD, Hayabuchi et al. identified pulmonary annular velocity as an encouraging echocardiographic parameter for describing RVOT performance¹³. According to another study, pulmonary annular velocity reflects RVOT's systolic activity, revealing information regarding overall RV function, pulmonary hypertension, right heart pressure, volume overload, and diseases including surgical damage to the RV

myocardium¹⁵. In literature, it has been revealed that RVOT functions decrease in patients with acute inferior MI, for which proximal RCA lesions are responsible, and RVOT-SE values can predict proximal RCA lesions²⁷. But RVOT anterior wall visualization with M-mode can be suboptimal in some patients, hindering RVOT-SE analyses. So, the PAMVUT could solve these limitations. Also, M-mode and TDI-based measurements made from the tricuspid annulus and the RV free wall to which it is joined may be wrongly high, notably in cases such as tricuspid regurgitation. The PAMVUT gives additional parameters for such conditions.

The present study has several limitations:

1. The study was a single-center study and had a non-randomized design.
2. It had a small number of patients.
3. We did not have cardiac magnetic resonance (CMR) imaging in our hospital, so we did not perform CMR, which is the gold standard for ventricular function.
4. Because of the absence of a clinical follow-up, we did not have prognostic information.

CONCLUSION

PAMVUT, which has been shown to be a good predictor of RVOT systolic functions, was used to see if it might predict proximal RCA occlusions in patients with acute inferior MI. Indeed, we found PAMVUT values to be an important predictor of proximal RCA occlusions.

Ethics Committee Approval: The local institutional ethics committee approved the investigation (Bolu Abant İzzet Baysal University Faculty of Medicine Ethics Committee, Ethics Committee Acceptance Number: 2021/130 and Date of Acceptance: 25/05/2021). Verbal and written informed consent forms were gathered from all participants.

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