Tricuspid annular motion in right coronary artery-related acute inferior myocardial infarction with or without right ventricular involvement

Sağ ventrikül tutulumunun eşlik ettiği ve etmediği sağ koroner arterle ilişkili akut inferiyor miyokart enfarktüsünde triküspit annülüs hareketi

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ABSTRACT

Objective: Tricuspid annular movement and velocities before and after thrombolytic therapy were investigated for the detection of right ventricular (RV) involvement in RCA (right coronary artery)-related acute inferior myocardial infarction (IMI).

Methods: Patients with RCA-related acute IMI were evaluated for this pilot prospective cohort study. Annular movement was measured by TAPSE (tricuspid annular plane systolic excursion), and annular velocities were measured by tissue Doppler echocardiography. Data collected before and after thrombolysis and angiography. Diagnosis of RV myocardial infarction (RVMI) was defined by co-presence of electrocardiographic and angiographic criteria. Chi-square and Student's t-tests were used in statistical analysis.

Results: Thirty-one patients were included. Before thrombolysis, annular velocities and TAPSE were found significantly higher in patients without RVMI than in patients with RVMI. Comparison of tricuspid systolic velocity (Sa) and movement before and after thrombolytic therapy in patients without RVMI revealed no significant difference (21.6±2.1 mm vs. 21.8±2.0 mm p>0.05 and 136.1±8.8 mm/s vs. 137.5±9.0 mm/s p>0.05, for TAPSE and Sa respectively). Contrarily, in patients with RVMI, TAPSE and systolic velocity increased significantly after thrombolysis compared with pre-thrombolysis (16.2±2.0 mm vs. 17.6±1.8 mm p=0.001 and 110.0±12.6 mm/s vs. 113.08±12.7 mm/s p=0.027 for TAPSE and Sa respectively). Diastolic velocities did not change significantly after thrombolysis in patients with RVMI.

Conclusion: Tricuspid annular movement and velocity measurement by echocardiography may contribute to echocardiographic diagnosis of RV involvement in RCA-related IMI. Patients without RVMI have significantly higher annular velocities and TAPSE than in patients with RVMI before thrombolysis. Only in IMI patients with RVMI, significant increases in TAPSE and Sa were observed after thrombolysis.

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Key words: Acute myocardial infarction, right ventricular infarction, thrombolytic therapy, coronary angiography, echocardiography, tissue Doppler echocardiography

ÖZET

Amaç: Sağ koroner arter (SKA) ile ilişkili akut inferiyor miyokardial enfarktüslü (İME) olgularda sağ ventrikül (SV) tutuluşunun saptanması için trombolitik tedavi öncesi ve sonrası triküspit annülüsün hareketi ve hızı araştırılmıştır.

Yöntemler: İlk SKA ile ilişkili akut İME'lü olgular bu pilot prospektif kohort çalışmasına alındı. Triküspit annülüs hareketi (TAPSE, tricuspid annular plane systolic excursion) ile, annüler hızlar ise ekokardiyografik doku Doppler'i ile ölçüldü. Veriler trombolitik tedaviden ve koroner anjiyografiden önce ve sonra kaydedildi. Sağ ventrikül miyokart enfarktüsü (SVME) elektrokardiyografik ve anjiyografik kriterlerin müşterek varlığı şeklinde tanımlandı. İstatistiksel analizde Ki-kare ve Student's t-testi kullanıldı.

Bulgular: Toplam 31 olgu çalışmaya alındı. Trombolitik tedavi öncesi annüler hızlar ve TAPSE, SVME'ü olmayan olgularda SVME olan olgulardan anlamlı derecede fazlaydı. Triküspit hızlarının ve hareketlerin trombolitik tedavi öncesi ve sonrası karşılaştırılması SVME olmayan olgularda anlamlı bir farklılık göstermedi (TAPSE ve sistolik triküspit hızı (Sa) için sırası ile 21.6±2.1 mm vs. 21.8±2.0 mm p>0.05 ve 136.0±8.8 mm/s vs. 137.5±9.0 mm/s, p>0.05). Tersine, SVME'ü olan olgularda TAPSE ve Sa trombolizis sonrası, trombolitik tedavi öncesine göre anlamlı derecede arttı (TAPSE ve Sa için sırası ile 16.2±2.0 mm vs. 17.6±1.8 mm p=0.001 ve 110.0±12.6 mm/s vs. 113.08±12.7 mm/s p=0.027).

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Sonuç: Triküspit annülüs hareketi ve hızı, SKA ile ilişkili İME'li hastalarda sağ ventrikül tutuluşunun ekokardiyografik tanısına katkıda bulunabilir. SVME'ü olmayan İME'li olgular SVME'lü olgulara göre trombolitik tedavi öncesinde anlamlı derecede daha yüksek triküspit annüler hız ve TAPSE değerlerine sahiptir. Sadece SVME'ü olan İME'lü olgularda trombolitik tedavi sonrası TAPSE değerlerinde ve sistolik hızlarda artış gözlenmiş, bu artışa diyastolik hızlanma eşlik etmemiştir. *(Anadolu Kardiyol Derg 2011; 11: 504-8)*
Anahtar kelimeler: Akut miyokart enfarktüsü, sağ ventrikül enfarktüsü, trombolitik tedavi, koroner anjiyografi, ekokardiyografi, doku Doppler ekokardiyografi

Introduction

Isolated right ventricular infarction is rare and usually occurs in association with inferior myocardial infarction (MI). The incidence of right ventricular (RV) infarction in such cases ranges from 10-50% in different series (1). The incidence is considerably higher in autopsy series (2). A possible explanation for this discrepancy is the difficulty in establishing this diagnosis in living subjects. Currently ST-segment elevation in electrocardiographic lead V4R is the single most powerful predictor of right ventricular involvement in the setting of inferior wall MI (3). When inferior MI is complicated by right ventricular infarction, in-hospital mortality is higher, as compared with isolated inferior MI (4). Early diagnosis and treatment of this association carries considerable importance.

We therefore examined the role of echocardiographic tricuspid annular movement and velocities for the detection of right ventricular involvement in patients with acute inferior wall MI. This study also evaluated post-thrombolytic changes in these echocardiographic parameters.

Methods

Study design and population

Patients with acute inferior MI were evaluated in this pilot prospective cohort study. Patients with prior MI, percutaneous coronary intervention and coronary artery surgery were not included. Patients presenting within 6 h of symptom's onset and at least 1-mm ST segment elevation in inferior leads were screened. According to the protocol, patients who cannot receive thrombolytic therapy were also excluded. Valvular heart disease, left ventricular systolic dysfunction, pulmonary hypertension and renal impairment (creatinine >1.2 mg/dl) were among other exclusion criteria. Patients with significant cardiac arrhythmia (including atrial fibrillation) were not included with the purpose of more accurate measurement of echocardiographic indices. Patient's informed consent was obtained prior to inclusion.

Protocol of the study

Baseline echocardiographic indices of tricuspid annular movement and velocities were obtained. All patients received thrombolytic therapy (Actilyse, Boehringer Ingelheim Pharma GmbH & Co. KG, Germany). Patients also received other guideline-recommended medications. Angiographic evaluation was performed within 24-48 h following thrombolysis. Echocardiographic measurements were repeated just before coronary angiography.

Echocardiography

Echocardiography was performed with Vivid 5 (GE, USA) machine with a 2.5 MHZ probe. Baseline echocardiographic data were collected immediately before the administration of thrombolytic therapy. Tricuspid annular movement was evaluated by measuring tricuspid annular plane systolic excursion (TAPSE). To obtain TAPSE, the apical four -chamber view was utilized, and an M-mode cursor was placed through the lateral tricuspid annulus. TAPSE was measured with the use of 2-dimensional guided M-mode recordings. The brightness was adjusted to maximize the contrast between the M-mode signal arising from the tricuspid annulus and the background. TAPSE was measured as the total displacement of the tricuspid annulus (centimeters) from end-diastole to end-systole, with values representing TAPSE (5). Echocardiographic data also included tissue Doppler imaging (TDI) of tricuspid annulus. Peak systolic, peak early and late diastolic velocities of tricuspid annulus (Sa, E' and A' respectively) were recorded from the lateral tricuspid annulus. To decrease intra-observer variability echocardiographic values were presented as the average of five measurements. These echocardiographic measurements were repeated just before coronary angiographic evaluation.

Coronary angiography

Patients underwent coronary angiography 24-48 hours after thrombolytic therapy. Coronary angiography was performed via femoral artery. Ioxalate meglumine (Hexabrix 320, Guerbet, France) was used as contrast agent. This study included only patients who had right coronary artery (RCA) related acute inferior MI. Patients with circumflex artery related inferior wall infarction were excluded. After inclusion of only RCA-related acute inferior MI, 34 patients were evaluated. Infarct-related culprit lesions on RCA were classified as proximal or distal in relation to major right ventricular branch of RCA.

Definition of right ventricular involvement

Electrocardiographic criterion for right ventricular infarction in inferior MI was defined as the presence of ≥1 mm ST-segment elevation at the right precordial lead V4R of electrocardiogram according to American Heart Association scientific statement on acute ischemia/infarction (3). Angiographic criterion for right ventricular involvement was defined as localization of angiographic culprit lesion before major right ventricular branch (proximal culprit lesion) of RCA.

For better identification of RV involvement, the diagnosis of RV infarction was defined by the co-presence of electrocardiographic and angiographic criteria. The absence of RV infarction

was defined by the absence of electrocardiographic criterion and localization of angiographic culprit lesion distal to the major right ventricular branch (distal culprit lesion).

Statistical analysis

Statistical analysis was performed using SPSS software (SPSS software for Windows, version 11.5 Chicago, IL, USA). Categorical data were compared with Chi-square statistics. Continuous data were presented as mean±standard deviation and/or median (minimum-maximum) and values displaying normal distribution (with Kolmogorov- Smirnov test) were compared with Student's paired and unpaired t-tests. A p value <0.05 was considered statistically significant.

Results

Thirty-four patients were evaluated. Two patients with proximal culprit lesion but without V4R ST segment elevation were excluded. One patient with distal culprit lesion and V4R ST segment elevation was also excluded. After these last exclusions, study group comprised of 31 patients. These patients were divided into 2 subgroups. Thirteen patients had an inferior MI with RV infarction (Group 1), and 18 patients had an inferior MI without RV infarction (Group 2).

TAPSE and annular velocities in patients with and without RVMI

Baseline characteristics of patients with and without right ventricular MI (RVMI) were comparable (Table 1). Comparison of patient groups with or without RVMI did not also reveal any significant difference according to the received medications. At admission, just before thrombolytic therapy, tricuspid annular velocities (peak systolic. early and late diastolic) and tricuspid annular movement were found significantly higher (p=0.001 for TAPSE, Sa and E' respectively, p=0.003 for A') in patients without RVMI than in patients with RVMI (Table 2).

Effects of thrombolytic therapy on TAPSE and annular velocities

After thrombolysis, in the entire study population, compared with pre-thrombolysis measurements, all these parameters were not significantly different (Table 3). Comparison of tricuspid velocities and movement before and after thrombolytic therapy in patients without RVMI also revealed a no significant difference (Table 3). In contrast in patients with RVMI, TAPSE value and systolic tricuspid velocity increased significantly (p=0.001 for TAPSE and p=0.027 for Sa) after thrombolysis compared with pre-thrombolysis measurements (Table 3). Contrarily, recovery of diastolic velocities was not observed following thrombolytic therapy in patient group with right ventricular involvement (Table 3). Basal and post-thrombolytic tricuspid annular diastolic E' and A' velocities did not differ significantly in this subgroup.

We also compared tricuspid annular kinetics in patients with and without RVMI after thrombolytic therapy. Tricuspid annular velocities and TAPSE values were still reduced significantly (p= 0.001 for TAPSE, Sa and E' respectively, p=0.003 for A') in patients with RVMI compared to patients without RVMI following thrombolytic therapy (Table 4).

Overt RV failure did not developed in any patient. Mortality developed in one patient in Group 2 during hospitalization period due to acute pulmonary embolism.

Discussion

The results of this study demonstrated that, tricuspid annular movement and velocity measurements by means of transthoracic echocardiography might contribute echocardiographic diagnosis of right ventricular involvement in patients with right coronary artery-related inferior myocardial infarction (IMI). Patients with RCA-related IMI and RV involvement were found significantly lower TAPSE measurements and tricuspid annular velocities comparing with IMI patients without RV involvement. In addition, TAPSE value and systolic tricuspid velocity increased

Table 1. Baseline characteristics of patients with and without right ventricular myocardial infarction

Characteristics	Inferior myocardial infarction		p*
	Group 1 (with RVMI)	Group 2 (w/o RVMI)	
Age, years	62 (43-74) 59±10	60 (41-76) 58±13	ns
Female gender, n (%)	5 (38)	7 (39)	ns
Hypertension, n (%)	6 (46)	8 (44)	ns
Diabetes mellitus, n (%)	2 (15)	3 (16)	ns
LVEF, %	55 (40-68) 53±7	57 (43-65) 54±6	ns

Data are expressed as median (minimum-maximum), mean±SD and as number (percentage)
*Chi-square and unpaired Student's t-tests
LVEF-left ventricular ejection fraction, RVMI-right ventricular myocardial infarction, ns-not significant , w/o - without

Table 2. Echocardiographic parameters of patients with and without right ventricular myocardial infarction before thrombolytic therapy

Variables	Inferior myocardial infarction		p*
	Group 1 (with RVMI)	Group 2 (w/o RVMI)	
TAPSE, mm	16.2±2.0 15.0 (14-21)	21.6±2.1 21.5 (18-25)	0.001
Sa, mm/s	110.0±12.6 113.0 (87-131)	136.1±8.8 135.0 (121-154)	0.001
E', mm/s	91.3±14.1 91.0 (71-120)	133.0±8.6 133.5 (108-145)	0.001
A', mm/s	132.1±10.6 132.0 (115-152)	146.4±13.1 148.0 (115-168)	0.003

Data are expressed as mean±SD and median (minimum-maximum) values
* unpaired Student's t-test
A' - peak late diastolic velocity, E' - peak early diastolic velocity, RVMI - right ventricular myocardial infarction, ns - not significant, Sa-peak systolic velocity TAPSE - tricuspid annular plane systolic excursion, w/o - without

Table 3. Echocardiographic parameters of study cohort, patients without right ventricular myocardial infarction, patients with right ventricular myocardial infarction before and after thrombolytic therapy

Parameter	Before thrombolysis	After thrombolysis	p*
Study cohort, (n=31)			
TAPSE, mm	19.3±3.3 19.0 (14-25)	20.1±2.8 20.0 (16-25)	ns
Sa, mm/s	125.1±16.7 126.0 (87-150)	127.2±16.1 128 (91-148)	ns
E', mm/s	116.1±22.6 126 (71-145)	118.2±23.5 129 (70-150)	ns
A', mm/s	140.4±13.9 141 (115-168)	142.0±13.3 143 (117-164)	ns
Group without RVMI, (n=18)			
TAPSE, mm	21.6±2.1 21.5 (18-25)	21.8±2.0 22.0 (18-25)	ns
Sa, mm/s	136.1±8.8 135.0 (121-154)	137.5±9.0 140 (121-148)	ns
E', mm/s	133.0±8.6 133.5 (108-145)	135.5±7.3 136.0 (120-150)	ns
A', mm/s	146.4±13.1 148.0 (115-168)	147.4±13.4 151.0 (117-164)	ns
Group with RVMI, (n=13)			
TAPSE, mm	16.2±2.0 15.0 (14-21)	17.6±1.8 17.0 (16-23)	0.001
Sa, mm/s	110.0±12.6 113.0 (87-131)	113.0±12.7 116.0 (91-136)	0.027
E', mm/s	91.3±14.1 91.0 (71-120)	94.3±15.4 96.0 (70-120)	ns
A', mm/s	132.1±10.6 132.0 (115-152)	134.4±9.3 133.0 (120-148)	ns

Data are expressed as mean±SD and median (minimum-maximum) values
*Student's t-test for paired samples
A'- peak late diastolic velocity, E'- peak early diastolic velocity, RVMI-right ventricular myocardial infarction, ns-not significant, Sa-peak systolic velocity, TAPSE- tricuspid annular plane systolic excursion

significantly after thrombolysis compared with pre-thrombolysis measurements only in patients with RVMI.

Isolated RV infarction is extremely rare. RVMI usually complicates 10-50% of inferior wall myocardial infarcts (1). Right ventricular involvement in patients with acute inferior MI is a clinically important problem. Patients with inferior MI who have RVMI appear to have a worse prognosis than those who do not have RV involvement (6-8). These patients are at increased risk of death, shock, and arrhythmias (8, 9). Currently ST segment elevation in the right precordial leads, particularly RV4, is the most powerful predictor of RV involvement in the setting of inferior wall MI (3, 10). The sensitivity of this finding is lower than specificity and even when strictly employed, however, the criteria lead to underestimation of the true incidence of right ventricular infarction. Although RV infarction is clinically evident in a sizeable number of cases, the incidence is considerably higher at autopsy. A major

Table 4. Echocardiographic parameters of patients with and without right ventricular myocardial infarction after thrombolysis

Variables	Inferior myocardial infarction		p*
	Group 1 (with RVMI)	Group 2 (w/o RVMI)	
TAPSE, mm	17.6±1.8 7.0 (16-23)	21.8±2.0 22.0 (18-25)	0.001
Sa, mm	113.0±12.7 116.0 (91-136)	137.5±9.0 140 (121-148)	0.001
E', mm	94.3±15.4 96.0 (70-120)	135.5±7.3 136.0 (120-150)	0.001
A', mm	134.4±9.3 133.0 (120-148)	147.4±13.4 151.0 (117-164)	0.003

Data are expressed as mean±SD and also as median (minimum-maximum) values
* unpaired Student's t-test
A' - peak late diastolic velocity, E' - peak early diastolic velocity, RVMI - right ventricular myocardial infarction, ns - not significant, Sa-peak systolic velocity, TAPSE - tricuspid annular plane systolic excursion, w/o - without

reason for this discrepancy is the lower sensitivity of electrocardiographic criterion for detection of RV infarction comparing with post-mortem analysis (11, 12). To be able to diagnose RV involvement more accurately in each case and to increase specificity in the study cohort, dual criteria were used. The diagnosis of RV infarction was defined by the presence of electrocardiographic and angiographic criteria. Right ventricular infarction was defined by the presence of electrocardiographic criterion and localization of angiographic culprit lesion proximal to the major right ventricular branch (proximal culprit lesion).

During recent years, echocardiography has made major advancement in the diagnosis of patients with right ventricular infarction (13). Echocardiography is also useful as a modality to rule out pericardial tamponade, which is the major differential diagnosis in the setting of right ventricular infarction. Classically right ventricular dilatation, abnormal right ventricular wall motion, paradoxical motion of the interventricular septum and tricuspid regurgitation are echocardiographic features of RVMI (13, 14). Echocardiography has 82% sensitivity and 93% specificity in detecting RVMI when right ventricular scintigraphy is used as the comparative standard (14).

Another echocardiographically obtained value that can aid in diagnosis of RV infarction is the myocardial performance index (MPI). MPI is derived from the sum of the isovolumic relaxation and contraction time divided by the ejection fraction. An abnormally elevated right ventricular MPI of >0.30 suggests the presence of RVMI in the presence of IMI (15).

Recently, the use of tissue Doppler in echocardiography has also increased, providing another means to detect right ventricular infarction. A decrease in the systolic velocity at the tricuspid annulus not only allows for diagnosis of right ventricular infarction but also suggests worse mortality outcome (16). In the study of Alam et al. (17), compared with patients without electrocardiographic signs of RVMI, patients with RVMI had a significantly decreased peak systolic tricuspid annular velocity and (13.3 and 10.3 cm/s, p<.001 respectively) and peak early diastolic velocity

(13 and 8.2 cm/s, p<0.001 respectively). According to the results of our study, in addition to the tricuspid annular velocities, TAPSE was significantly lower in patients with RVMI than in patients without RVMI. Current study demonstrated that patients with RVMI had significantly reduced tricuspid annular motion and velocities compared to patients without RVMI before and after thrombolytic therapy. In the entire study population and in the patient group without RVMI, echocardiographic parameters of tricuspid kinetics did not changed significantly following thrombolysis compared to basal measurements. On the other hand, in patient group with RVMI, TAPSE values and systolic velocities were found significantly increased following thrombolysis.

Study limitations

We evaluated tricuspid annular movement and velocities before and after thrombolytic therapy in RCA-related IMI patients with or without RVMI. It would be better to relate the echocardiographic measures with the information about patency and flow of the infarct-related right coronary artery. In the study population, after thrombolysis, especially the number of patients who had occluded RCA is too low to make a statistical comparison. In a larger study cohort, comparison of echocardiographic parameters of patient with or without RVMI according to the patency and TIMI flow of infarct related artery may provide more information about kinetics of tricuspid annulus in RCA-related IMI.

In this study, we also did not seek correlation between classical echocardiographic findings of RVMI and tricuspid annular kinetics. After demonstration of significant difference between patient groups with and without RVMI according to tricuspid annular movement and velocities, this study may serve as a pilot, hypothesis-generating study for future studies.

Conclusion

Tricuspid annular movement and velocity measurements by means of transthoracic echocardiography may contribute echocardiographic detection of right ventricular involvement in patients with RCA- related IMI. Patients with RVMI had significantly reduced tricuspid annular motion and velocities compared to patients without RVMI before and after thrombolytic therapy. Only in IMI patients with RVMI, significant increases of TAPSE values and systolic velocities but not diastolic velocities were observed soon after thrombolytic therapy.

Conflict of interest: None declared.

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