



## Dijastolička funkcija lijeve klijetke u akutnom infarktu miokarda

## Left ventricular diastolic function in acute myocardial infarction

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**SAŽETAK:** Poremećaj dijastoličke funkcije lijeve klijetke (LK) je jedan od prvih poremećaja funkcije LK, koji se registri-  
raju prije poremećaja regionalnog kontraktiliteta, EKG promje-  
na i bola u prsnom košu, što bitno mijenja prognozu pacijena-  
ta s akutnim koronarnim sindromom. Poremećaj relaksacije  
LK često se registrira u pacijenata s akutnim infarktom miokar-  
da (AIM), a poremećaj krutosti LK u pacijenata s AIM prednje  
stijenke. Najizraženija dijastolička abnormalnost uzrokovana  
ishemijom miokarda je produžena i usporena relaksacija mio-  
karda. Ehokardiografske tehnike omogućavaju evaluaciju di-  
jastoličkog punjenja obje pretklijetke i klijetke.

Cilj ovog rada je bio utvrditi dijastoličku funkciju LK u bo-  
lesnika s AIM i usporediti varijable dijastoličke funkcije u sku-  
pinama bolesnika s AIM anteroseptalne i inferiorne stijenke.

U prospektivno istraživanje uključeno je 60 bolesnika (37  
muškaraca, prosječne životne dobi 59±10 godina) s prvim  
AIM koji su podijeljeni u dvije skupine prema lokalizaciji EKG  
promjena (anteroseptalna naspram inferiorne stijenke). Pra-  
ćene su varijable dijastoličke funkcije LK koje su analizirane  
kontinuiranom (mitralni protok) i pulsnom kolor Doppler eho-  
kardiografskom tehnikom (protok u plućnim venama i pokreti  
mitralnog prstena).

Vrijednosti brzina ranog dijastoličkog punjenja nisu se sta-  
tistički značajno razlikovale u obje skupine, ali je bila niža u  
odnosu na prosječnu vrijednost brzine ranog dijastoličkog pu-  
njenja LK kod zdravih osoba. U maksimalnoj brzini sistoličkog  
protoka plućnih vena registrirana je statistički značajna razli-  
ka ( $p<0,05$ ) između ispitivanih skupina. U prvoj skupini iz-  
nosila je 0,48±0,10, a u drugoj iznosila je 0,57±0,14. Maksi-  
malna brzina dijastoličkog protoka plućnih vena u prvoj sku-  
pini iznosila je 0,37±0,09, a u drugoj skupini iznosila je  
0,43±0,16. Odnos maksimalne brzine sistoličkog i dijastolič-  
kog protoka plućnih vena je nešto veći nego kod zdravih oso-  
ba. U bolesnika s AIM dominira (70%) dijastolička disfunkcija  
tipa poremećaja relaksacije LK. U ispitivanoj skupini bolesni-  
ka s anteroseptalnim AIM dijastolička disfunkcija tipa pore-  
mećaja relaksacije je dominantna, odnosno registrirana je sta-  
tistički značajna razlika u odnosu na očuvanu dijastoličku  
funkciju i na dijastoličku disfunkciju tipa poremećaja restrikti-  
je LK ( $p<0,05$ ).

Zaključno, kod AIM, kako anteroseptalne tako i inferiorne  
stijenke, promijenjeni su parametri dijastoličke funkcije, od-  
nosno prisutna su sva tri stupnja dijastoličke disfunkcije LK.  
Dominira dijastolička disfunkcija tipa poremećaja relaksacije  
miokarda. U AIM anteroseptalne stijenke najviše je prisutna  
dijastolička disfunkcija tipa poremećaja relaksacije, odnosno  
postoji dobra korelacija s infarciranom zonom u odnosu na in-  
feriornu stijenku.

**KLJUČNE RIJEČI:** akutni infarkt miokarda, ehokardiografi-  
ja, dijastolička funkcija.

**SUMMARY:** Left ventricular (LV) diastolic dysfunction is  
one of the first LV function abnormalities, which is detected  
before the regional disorder of contractility, ECG changes and  
chest pains, which significantly changes the prognosis of pa-  
tients with acute coronary syndrome. The disorder of LV relax-  
ation is often detected in patients with acute myocardial in-  
farction (AMI), a disorder of LV stiffness in patients with ante-  
rior wall AMI. The most pronounced diastolic abnormality  
caused by myocardial ischemia is prolonged and delayed my-  
ocardial relaxation. Echocardiographic techniques allow the  
evaluation of diastolic filling of the both atria and ventricles.

The aim of this study was to determine the LV diastolic  
function in patients with AMI and compare the diastolic func-  
tion variables in the groups of patients with anteroseptal and  
inferior wall AMI.

The prospective trial included 60 patients (37 men; mean  
age 59±10) with first AMI who were divided into two groups  
according to the localization of ECG changes (anteroseptal vs.  
inferior wall). LV diastolic function variables were monitored  
that were analyzed by continuous (mitral flow) and pulsed col-  
or Doppler echocardiography technique (flow in the pulmo-  
nary veins and mitral ring motions).

The value of velocity of early diastolic filling was not stati-  
stically significantly different in the both groups, but it was lo-  
wer compared to the average value of the velocity of the early  
diastolic filling of LV in healthy persons. In the maximum  
velocity of systolic pulmonary venous flow, a statistically signifi-  
cant difference was recorded ( $p<0,05$ ) among the groups of pa-  
tients. In the first group it was 0.48±0.10, while in the second  
group it was 0.57±0.14. Maximum velocity of diastolic pul-  
monary venous flow in the first group was 0.37±0.09, while in  
the second group it was 0.43±0.16. The ratio of maximum ve-  
locity of systolic and diastolic pulmonary venous flow was  
slightly higher than in healthy individuals. In patients with AMI,  
diastolic dysfunction of the LV relaxation disorder type pre-  
vails (70%). In the examined group of patients with anterosep-  
tal AMI, diastolic dysfunction of the relaxation disorder type  
prevails, that is, a statistically significant difference compared  
to the normal diastolic function and diastolic dysfunction of  
the LV restriction disorder type ( $p<0,05$ ) is recorded.

Finally, in case of anteroseptal and inferior wall AMI, the  
parameters of diastolic function are changed, that is, all three  
degrees of LV diastolic dysfunction are present. Diastolic dys-  
function of myocardial relaxation disorder type prevails. In an-  
teroseptal wall AMI, diastolic dysfunction of relaxation disor-  
der type is mostly present, that is in good correlation with in-  
farcted zone in relation to the inferior wall.

**KEYWORDS:** acute myocardial infarction, echocardiogra-  
phy, diastolic function.

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Srčanožilne bolesti svojom učestalosti, epidemijskim zamahom, sociomedicinskim posljedicama od privremenog do trajnog invaliditeta uz visoku smrtnost, postaju najveći problem suvremene medicine. Akutni infarkt miokarda (AIM) predstavlja jedan od vodećih javnozdravstvenih problema u industrijskim zemljama i postaje veoma značajan u zemljama u razvoju.<sup>1</sup> Bosna i Hercegovina pripada u skupinu zemalja u tranziciji i ima stalan porast pobola (porast s 838 na 1.150/10.000 stanovnika u razdoblju od 1998. do 2008. godine u FBiH) i smrtnosti (porast s 39 na 45/10.000 stanovnika u razdoblju od 1999. do 2008. god. u FBiH) od srčanožilnih bolesti. Porast pobola bilježi se također i za AIM, a iznosi 13-16,1/10.000 stanovnika u razdoblju od 2004. do 2008. god. u FBiH. Vodeći uzroci smrti 2009. god. u FBiH, kao i prethodnih godina, predstavljaju bolesti cirkulatornog sistema s udjelom od 53,4%. Među pet vodećih uzroka smrti u 2009. godini u FBiH je AIM s 8%, uz odnos žena naspram muškaraca koji iznosi 7% naspram 9%.<sup>2</sup>

U AIM najčešće komplikacije su (sistolicka i/ili dijasistolicka) disfunkcija lijeve klijetke (LK), srčano popuštanje, poremećaji srčanog ritma i provođenja, ruptura zidova LK, arterijska hipotenzija, kardiogeni šok, aneurizma LK, perikarditis, venska i plućna tromboembolija, rekurentna ishemija i infarkt i drugo.<sup>3</sup> Poremećaj dijasistolické funkcije LK predstavlja jedan od prvih poremećaja funkcije LK, koji se registrira prije poremećaja regionalnog kontraktiliteta, EKG promjena i bola, što bitno mijenja prognozu pacijenata s akutnim koronarnim sindromom.<sup>4</sup> Poremećaj relaksacije LK često se registrira u pacijenata s AIM, a poremećaj krutosti LK se registrira u pacijenata s AIM prednje stijenke.<sup>5</sup> Najizraženija dijasistolická abnormalnost uzrokovana ishemijom miokarda je produžena i usporena relaksacija miokarda. Ukoliko je infarktom zahvaćeno 8% miokarda LK već se može pojaviti redukcija u dijasistolické rastegljivosti. Povećanje enddijasistolického tlaka i volumena može se javiti kada infarcirana zona dosegne 15% od ukupnog miokarda LK. Ehokardiografske tehnike omogućavaju evaluaciju dijasistolického punjenja obje klijetke i pretklijetke.

## Cilj rada

Utvrđiti dijasistolicku funkciju LK u bolesnika s AIM anteroseptalne i inferiorne stijenke i usporediti varijable dijasistolické funkcije LK u skupinama bolesnika s AIM anteroseptalne i inferiorne stijenke.

## Ispitanici i metode

Učinjeno je prospektivno istraživanje kod 60 bolesnika (37 muškaraca, prosječne životne dobi 59±10 godina) s prvim AIM u razdoblju od ožujka 2006. do studenoga 2007. godine u Klinici za interne bolesti Univerzitetskog kliničkog centra Tuzla koji su podijeljeni u dvije skupine. U prvu skupinu uključeni su ispitanici s AIM anteroseptalne stijenke, dok drugu skupinu čine ispitanici s AIM inferiorne stijenke. Svi ispitanici su imali očuvanu sistoličku funkciju LK s e젝cijskom frakcijom >50% utvrđenu Simpsonovom metodom u apikalnom presjeku sa 4 ili 2 šupljine. U istraživanje nisu uključeni ispitanici s poremećajem ritma po tipu fibrilacije atrija, težim stupnjem valvularne bolesti srca i hipertrofije LK.

Cardiovascular diseases with their prevalence, epidemic momentum, sociomedical consequences from temporary to permanent disability, followed by a high mortality rate, are becoming the biggest problem of modern medicine. Acute myocardial infarction (AMI) is one of the leading public health problems in industrialized countries and is becoming very important in the developing countries.<sup>1</sup> Bosnia and Herzegovina belongs to a group of countries in transition and has a steady increase in morbidity (rate increase with 838-1,150/10,000 of population during the period from 1998 to 2008 in the FB&H) and mortality (rate increase 39-45/10,000 of population during the period from 1999 to 2008 in the FB&H) from cardiovascular diseases. The increase in rate of morbidity is also recorded for AMI, which amounts to 13-16.1/10,000 of inhabitants during the period from 2004 to 2008 in the FB&H. The leading causes of death in 2009 in the FB&H as during the previous years are the diseases of the circulatory system amounting to 53.4%. AMI is with 8% among the five leading causes of mortality in 2009 in the FB&H, with ratio of women vs. men which is 7% vs. 9%.<sup>2</sup>

In AMI the most common complications are (systolic and/or diastolic) left ventricular (LV) dysfunction, heart failure, heart rhythm and conduction disorders, LV wall rupture, arterial hypotension, cardiogenic shock, LV aneurysm, pericarditis, venous and pulmonary thromboembolism, recurrent ischemia, infarction etc.<sup>3</sup> LV diastolic function disorder is one of the first LV function disorders, which is detected prior to the disorder of regional contractility, ECG changes and pain, which significantly changes the prognosis of patients with acute coronary syndrome.<sup>4</sup> LV relaxation disorder is often recorded in patients with AMI, while the LV stiffness disorder is recorded in patients with anterior wall AMI.<sup>5</sup> The most pronounced diastolic abnormality caused by myocardial ischemia is prolonged and delayed myocardial relaxation. If the infarction has affected 8% of the myocardium of LV, a reduction can appear in compliance of LV. Elevation of end-diastolic pressure and volume can occur when infarcted zone reaches 15% of the total LV myocardium. Echocardiographic techniques allow evaluation of diastolic filling of the both ventricles and atria.

## Aim

The aim of this study was to determine the LV diastolic function in patients with anteroseptal and inferior wall AMI and compare the variables of LV diastolic functions in the groups of patients with anteroseptal and inferior wall AMI.

## Patients and methods

Prospective study was conducted in 60 patients (37 men; mean age 59±10 years) with first AMI during the period from March 2006 to November 2007 in the Clinic for Internal Diseases of the University Clinical Centre Tuzla, which were divided into two groups. The first group consists of the patients with anteroseptal wall AMI, while the other group consists of patients with inferior wall AMI. All patients had normal LV systolic function with ejection fraction >50% as determined by Simpson method in apical 4 or 2 chamber view. The study did not include patients with the rhythm disorder of the atrial fibrillation type, severe degree of valvular heart disease and LV hypertrophy.



Dijagnoza AIM postavljena je elektrokardiografskim, ehokardiografskim i potvrđena biokemijskim biljezima (troponin, kreatin kinaza izoenzim MB). Lokalizacija infarctirane zone stijenke određena je pomoću 12-kanalnog EKG i dvodimenzijske ehokardiografije. Ehokardiografski pregled učinjen je u prvih 24 sata od nastanka AIM na aparatu VIVID 3 *General Electric* uz korištenje multifrekventne kardiološke sonde (1,7-3,6 MHz). Varijable dijasoličke funkcije LK su određene kontinuiranom (mitralni protok) i pulsnom kolor Doppler tehnikom (protok u plućnim vena i pokreti mitralnog prstena).

U statističkoj obradi podataka korištene su standardne metode deskriptivne statistike. Za testiranje statističke značajnosti razlika među uzorcima primjenjeni su parametrijski i neparametrijski testovi značajnosti ( $\chi^2$ -test, Studentov t-test), kao i metoda linearne korelacije. Statističke hipoteze testirane su na nivou značajnosti od  $\alpha=0,05$ , tj. razlika među uzorcima smatrana je značajnom ako je  $p<0,05$ .

## Rezultati

Demografski podaci 60 ispitanika prikazani su na **Slikama 1, 2 i 3**, kao i u **Tablici 1**. U skupinu s AIM antero-septalne stijenke uključeno je 27 (45%), a u skupinu s AIM inferiorne stijenke 33 (55%) ispitanika. Prosječna životna dob iznosila je  $59\pm 10$  (37-79 godina). U obje skupine zastupljenost osoba muškog spola iznosila je 37 (61,7%) ispitanika, a žena 23 (38,3%). Zastupljenost muškaraca u pr-

The diagnosis of AMI is made by electrocardiography, echocardiography and is confirmed by biochemical markers (troponin, creatine kinase MB isoenzyme). The localization of infarcted wall zone is determined by using 12-channel ECG and two-dimensional echocardiography. Echocardiography was performed in the first 24 hours from the occurrence of AMI on the apparatus VIVID 3 *General Electric* by using multifrequency cardiac probe (1.7 to 3.6 MHz). The variables of LV diastolic function are determined by continuous (mitral flow) and pulsed color Doppler techniques (flow in the pulmonary veins and mitral ring movements).

The statistical analysis of data used standard methods of descriptive statistics. Parametric and non-parametric significance tests ( $\chi^2$ -test, Student's t-test) and linear correlation methods were used for testing the statistical significance of differences among the samples. The statistical hypotheses were tested at the level of significance from  $\alpha=0.05$ , i.e. the difference between the samples was considered significant if  $p<0.05$ .

## Results

Demographic data of 60 patients are shown in **Figures 1, 2 and 3** and in **Table 1**. The group with antero-septal wall AMI included 27 (45%) and the group with inferior wall AMI included 33 (55%) of patients. The average age was  $59\pm 10$  years (37-79 years of age). In the both groups, the frequency of the male gender was 37 (61.7%) and 23 women (38.3%). The representation of men in the first

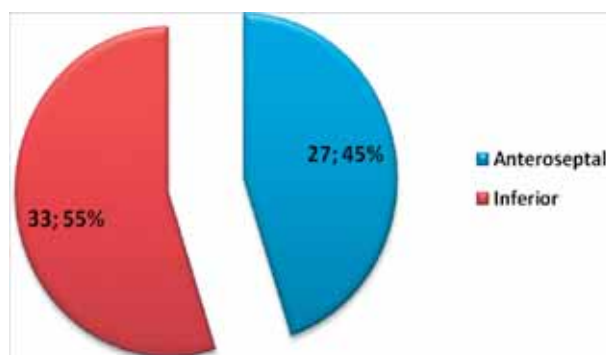


Figure 1 Groups of patients according to acute myocardial infarction localisation.

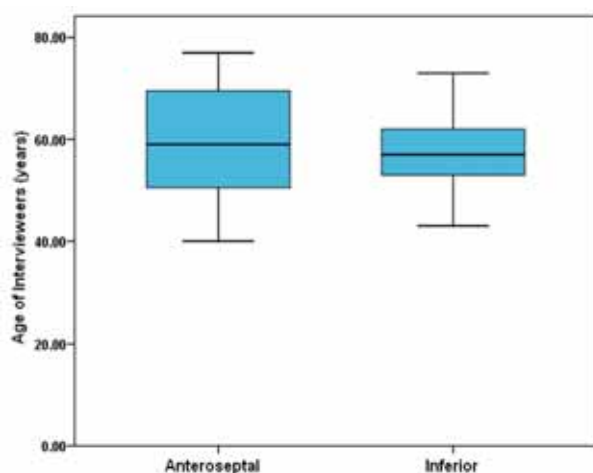


Figure 2. Average age in the groups of patients.

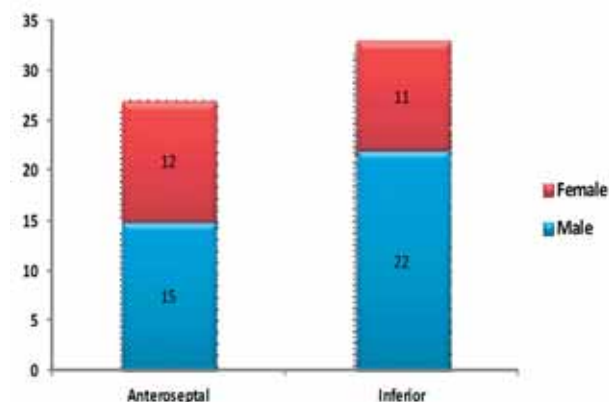


Figure 3. Groups of patients according to gender.

**Table 1.** Risk factors incidence in patients with acute myocardial infarction.

Localisation of myocardial infarction	Arterial hypertension		Diabetes mellitus		Smoking		Hyperlipoproteinaemia		Positive familial history	
	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
Anteroseptal	13 (21,66%)	14	6 (10%)	21	10 (16,66%)	17	11 (18,33%)	16	10 (16,66%)	17
Inferior	11 (18,33%)	22	6 (10%)	27	13 (21,66%)	20	13 (21,66%)	20	7 (11,66%)	26
Total	24 (40%)	36	12 (20%)	48	23 (38,33%)	37	24 (40%)	36	17 (28,33%)	43

voj skupini iznosila je 15 (55,5%), a žena 12 (44,4%). U drugoj skupini bilo je 22 muškarca (66,66%) i 11 (33,3%) žena.

Od čimbenika rizika registrirani su arterijska hipertenzija i hiperlipoproteinemija u 24 (40%), a pušenje u 23 (38,3%) ispitanika. Pozitivna obiteljska anamneza registrirana je u 17 (28,3%), a dijabetes u 12 (20%) ispitanika. U prvoj skupini nađena je arterijska hipertenzija u 13 (21,6%), a u drugoj skupini 11 (18,3%) ispitanika.

U skupini ispitanika s anteroseptalnim AIM registrirana je hiperlipoproteinemija u 11 (18,3%), a u skupini s inferiornim AIM u 13 (21,6%) ispitanika. U prvoj skupini bilo je 10 (16,6%), a u drugoj skupini 13 (21,6%) pušača. Pozitivna obiteljska anamneza registrirana je u 10 (16,6%) ispitanika u prvoj skupini i kod njih 7 (11,6%) u drugoj skupini. U obje skupine ispitanika bio je jednak broj dijabetičara, po 6 (10%) ispitanika. Indeks tjelesne mase u prvoj skupini iznosio je  $27,7 \pm 4,2$ , a u drugoj skupini  $27,8 \pm 4,1$  kg/m<sup>2</sup>. Nije registrirana statistički značajna razlika prema dobi, spolu, indeksu tjelesne mase i učestalosti čimbenika rizika između dvije skupine ispitanika ( $p > 0,05$ ).

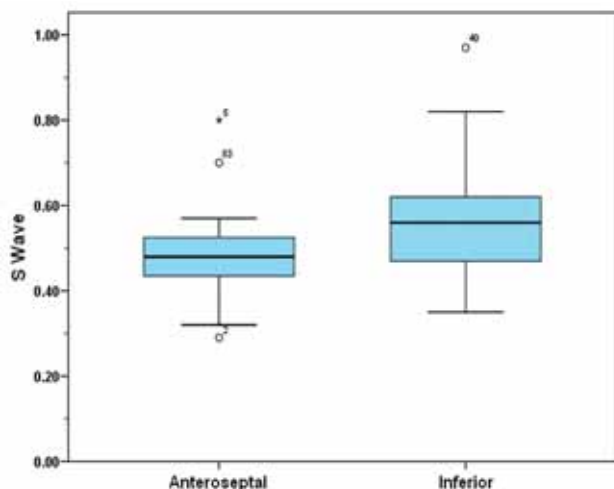
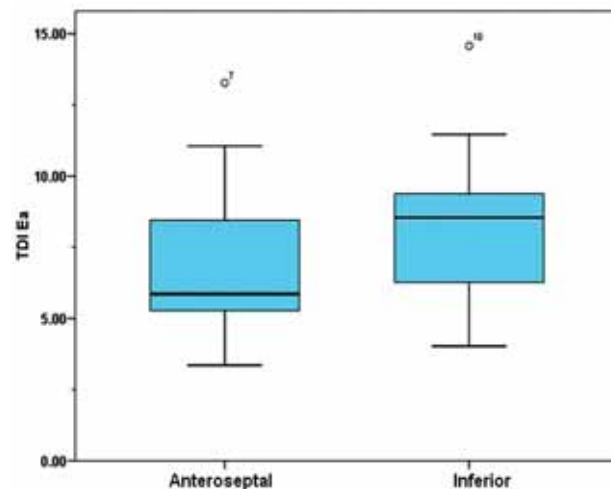
Učinjena je usporedba svih analiziranih varijabli diastoličke funkcije LK između obje skupine ispitanika, čije su prosječne vrijednosti prikazane u **Tablici 2**. Nije registrirana statistički značajna razlika u praćenim varijablama diastoličke funkcije LK ( $p > 0,05$ ), osim u sistoličkom protoku

group was 15 (55.6%) and women 12 (44.4%). The second group consisted of 22 men (66.7%) and 11 (33.3%) women.

Considering the risk factors, hypertension and hyperlipoproteinemia were recorded in 24 (40%), and smoking was recorded in 23 (38.3%) examinees. Positive family history was recorded in 17 (28.3%), and diabetes in 12 (20%) of examinees. In the first group, hypertension was found in 13 (21.7%) and in the second group in 11 (18.3%) of patients.

In the group of patients with anteroseptal AMI, hyperlipoproteinemia was recorded in 11 (18.3%) and in the group with inferior AMI it was recorded in 13 (21.6%) patients. In the first group there were 10 (16.6%), while in the second group there were 13 (21.6%) smokers. Positive family history was recorded in 10 (16.6%) examinees in the first group and in 7 of them (11.6%) in the second group. In the both groups of patients there was an equal number of diabetics, 6 (10%) in each group. Body mass index in the first group was  $27.6 \pm 4.2$ , while in the second group it was  $27.8 \pm 4.1$  kg/m<sup>2</sup>. The statistically significant difference by age, gender, body mass index and prevalence of risk factors between the two groups ( $p > 0.05$ ) was not recorded.

The comparison of all the analyzed variables of LV diastolic function was made between the both groups, whose average values are shown in **Table 2**. Statistically significant difference in the monitored variables of LV diastolic function was not recorded ( $p > 0.05$ ), except in the systolic

**Figure 4.** Mean systolic flow value in pulmonary veins.**Figure 5.** Mean value of early mitral ring motion velocity.



**Table 2.** Average values of left ventricular diastolic functions.

	Localisation of myocardial infarction	Percentage	Std. deviation	Percentage in both groups
E wave	Anteroseptal	0.67	0.16	0.69
	Inferior	0.70	0.22	
A wave	Anteroseptal	0.82	0.26	0.81
	Inferior	0.80	0.25	
E/A	Anteroseptal	0.93	0.47	0.95
	Inferior	0.96	0.47	
DT	Anteroseptal	235.85	65.83	231.17
	Inferior	227.33	60.42	
MVADur	Anteroseptal	119.00	17.60	120.83
	Inferior	122.33	18.54	
IVRT	Anteroseptal	98.74	18.04	98.78
	Inferior	98.82	20.18	
S wave	Anteroseptal	0.48*	0.10	0.53
	Inferior	0.57*	0.14	
D wave	Anteroseptal	0.37	0.09	0.40
	Inferior	0.43	0.16	
S/D	Anteroseptal	1.38	0.40	1.41
	Inferior	1.43	0.40	
AR wave	Anteroseptal	0.30	0.07	0.30
	Inferior	0.30	0.07	
PVAdur	Anteroseptal	137.15	22.57	135.48
	Inferior	134.12	27.29	
TDI Ea	Anteroseptal	6.87*	2.53	7.53
	Inferior	8.08*	2.29	
TDI Aa	Anteroseptal	8.29	2.39	8.78
	Inferior	9.18	2.95	
TDI E/A	Anteroseptal	0.93	0.49	0.98
	Inferiorni	1.03	0.58	
Vp	Anteroseptal	55.85	16.34	56.33
	Inferior	56.73	12.49	

\*significant difference  $p < 0.05$

plućnih vena (S val) ( $p < 0.01$ ) i u vrijednostima brzine ravnog pokreta mitralnog prstena (TDI Ea) ( $p < 0.05$ ). U prvoj skupini srednja vrijednost S vala iznosila je  $0,48 \pm 0,10$ , a u drugoj skupini je bila veća i iznosila  $0,57 \pm 0,14$  (Slika 4). U prvoj skupini (Slika 5) prosječna vrijednost TDI Ea vala bila je niža u odnosu na drugu skupinu ( $6,87 \pm 2,53$  naspram  $8,08 \pm 2,29$ ). Vrijednost TDI Ea vala je izračunata od srednje vrijednosti septalnog i lateralnog TDI Ea vala.

Uspoređene su i frekvencije očuvane dijastoličke funkcije i tipova dijastoličke disfunkcije LK između obje skupine ispitanika, što je prikazano u Tablici 3. U obje skupine ispitanika registrirano je 18 (30%) ispitanika s očuvanom dijastoličkom funkcijom LK. Dijastolička disfunkcija LK registrirana je u 42 (70%) ispitanika. Dijastolička disfunkcija tipa produžene relaksacije miokarda registrirana je u 38 (63,3%), a tipa restrikcije u 4 (6,7%) ispitanika.

U prvoj skupini registrirano je 6 (22,2%) ispitanika s očuvanom dijastoličkom funkcijom LK, dok je poremećaj dijastoličke funkcije registriran u njih 21 (77,8%). Dijastolička disfunkcija tipa produžene relaksacije miokarda registrirana je u 19 (57,6%), a tipa restrikcije u 2 (7,4%) ispitanika. U drugoj skupini registrirano je 12 (36,4%) ispitanika s očuvanom dijastoličkom funkcijom, a dijastolička

pulmonary venous flow (S wave) ( $p < 0.01$ ) and in the values of velocity of early mitral ring motion (TDI Ea) ( $p < 0.05$ ). In the first group, the mean S wave was  $0.48 \pm 0.10$ , while in the second group it was higher and amounted to  $0.57 \pm 0.14$  (Figure 4). In the first group (Figure 5) the average value of TDI Ea wave was lower compared to the other group ( $6.87 \pm 2.53$  vs.  $8.08 \pm 2.29$ ). The value of TDI Ea wave was calculated from the mean value of septal and lateral TDI Ea wave.

The frequency of normal diastolic function and types of LV diastolic dysfunction were compared between the both groups, as shown in Table 3. In both groups there were 18 (30%) of patients with normal LV diastolic function detected. LV diastolic dysfunction was recorded in 42 (70%) of patients. Diastolic dysfunction of the prolonged myocardial relaxation type was recorded in 38 (63.3%), and restriction type in 4 (6.7%) of patients.

In the first group, 6 (22.2%) of patients with LV normal diastolic function was recorded, while the diastolic dysfunction was recorded in 21 of them (77.8%). Diastolic dysfunction of the prolonged myocardial relaxation type was recorded in 19 (57.6%), and restriction type in 2 (7.4%) of examinees. In the second group there were 12 (36.4%) patients with normal diastolic function and dia-

**Table 3.** Disorders of left ventricular diastolic function.

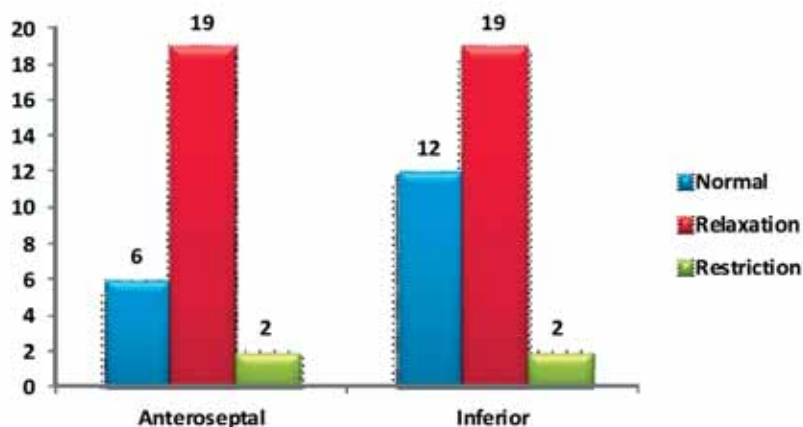
		Left ventricular diastolic function			
		Normal	Disorder of Relaxation	Restriction	Total
Localisation of myocardial infarction	Anteroseptal	N 6 % 22.2%	19 70.4%	2 7.4%	27 100.0%
	Inferior	N 12 % 36.4%	19 57.6%	2 6.1%	33 100.0%
Total		N 18 % 30.0%	38 63.3%	4 6.7%	60 100.0%

disfunkcija registrirana je u 21 (63,7%) ispitanika. Dijastolička disfunkcija LK tipa produžene relaksacije miokarda registrirana je kod 19 (57,6%), a tipa restrikcije kod 2 (6,1%) ispitanika. Nije registrirana statistički značajna razlika u učestalosti prisustva pojedinih tipova dijastoličke disfunkcije između dvije skupine ispitanika ( $\chi^2=1,41$ ;  $df=2$ ;  $p=0,49$ ).

U skupini ispitanika s anteroseptalnim AIM registrirana je statistički značajna razlika između ispitanika s očuvanom dijastoličkom funkcijom i onih s dijastoličkom disfunkcijom tipa produžene relaksacije miokarda LK ( $p<0,05$ ). Također, u istoj skupini ispitanika registrirana je statistički značajna razlika između ispitanika s očuvanom dijastoličkom funkcijom i dijastoličkom disfunkcijom LK ( $p<0,05$ ). Grafički prikaz dijastoličke funkcije LK u obje skupine ispitanika prikazan je na **Slici 6**.

stolic dysfunction was recorded in 21 (63.7%). LV diastolic dysfunction of prolonged myocardial relaxation type was recorded in 19 (57.6%), and a restriction type in 2 (6.1%) examinees. Statistically significant difference in frequency of the presence of certain types of diastolic dysfunction between the two groups was not recorded ( $\chi^2=1.41$ ;  $df=2$ ;  $p=0.49$ ).

In the group of patients with anteroseptal AMI, statistically significant difference among the patients with normal diastolic function and those with diastolic dysfunction type of LV prolonged myocardial relaxation ( $p<0.05$ ) was detected. Also, in the same group a statistically significant difference between the patients with normal diastolic function and LV diastolic dysfunction ( $p<0.05$ ) was detected. The graphic image of LV diastolic function in the both groups of patients is shown in **Figure 6**.

**Figure 6.** Graphic image of left ventricular diastolic function according to groups of patients.

## Diskusija

Ispitivana skupina bolesnika s AIM u ovoj studiji pripada u srednju dobnu skupinu starosti  $59\pm 10$  (37-79 godina), s nešto većom zastupljenošću muškaraca (61,7%) u odnosu na žene (38,3%). Iako su ispitanici u skupini s AIM inferiorne stijenke pokazali manji raspon u dobnoj strukturi u odnosu na ispitanike iz skupine s AIM anteroseptalne stijenke nije postojala statistički značajna razlika u dobi između obje skupine ( $p>0,05$ ).

## Discussion

The group of patients with AMI in this study falls into the middle aged group  $59\pm 10$  (37-79 years), with slightly higher representation of males (61.7%) than women (38.3%). Although the patients in the group with inferior wall AMI showed a smaller age range compared to the group of patients with anteroseptal AMI there was no statistically significant difference in age between the both groups ( $p>0.05$ ).



Učestalost srčanožilnih bolesti je oko tri puta veća kod muškaraca.<sup>6</sup> Od do sada poznatih kardiovaskularnih čimbenika rizika registrirani su: arterijska hipertenzija, dijabetes, pušenje, hiperlipoproteinemija, pretilost i pozitivna obiteljska anamneza. Pušenje predstavlja značajan čimbenik rizika obzirom da značajno povećava mogućnost nastanka srčanožilnih bolesti kod muškaraca.<sup>7</sup> U menopauzi se kod osoba ženskog spola izlučuju manje količine estrogena. Uslijed toga dolazi do poremećaja međusobnog odnosa metabolizma lipida i tako se povećava rizik za razvoj srčanožilnih bolesti.<sup>8</sup> Najznačajniji čimbenici rizika za nastanak AIM predstavljaju pušenje i abnormalnost lipida, koja se ogleda u međusobnom odnosu apolipoproteina A i B (ApoB/ApoA1). Sljedeći značajni čimbenici rizika su dijabetes i arterijska hipertenzija, što je ovo istraživanje i pokazalo. Dijabetes povećava rizik za razvoj AIM zato što povećava učestalost progresije ateroskleroze. Sistolička i dijastolička arterijska hipertenzija udružena je s povećanim rizikom za razvoj AIM, kao i pozitivna obiteljska anamneza (prisustvo ishemijske bolesti srca kod rođaka prvog stupnja od oboljele osobe prije 55 godine života kod muškaraca i prije 65 godine života kod žena). Relativni značaj svakog čimbenika rizika varira i uglavnom je u odnosu s njegovom prevalencijom. Hiperlipoproteinemije, pušenje te psihosocijalni faktori predstavljaju najznačajnije čimbenike rizika diljem svijeta. Gore spomenuti čimbenici kada su udruženi imaju kumulativni učinak i tako značajno povećavaju rizik za nastanak AIM.<sup>9,10</sup>

Dijastolička disfunkcija predstavlja rani pokazatelj bolesti u zahvaćenom srcu i najčešće prethodi sistoličkoj disfunkciji. Primarna dijastolička disfunkcija podrazumijeva normalnu sistoličku funkciju LK. Doppler ehokardiografija predstavlja vrlo osjetljivu metodu u dokazivanju normalnog i poremećenog rada srca tokom diastole.<sup>11</sup> Mjerenja dijastoličke funkcije LK metodom Doppler ehokardiografije mogu predvidjeti klinički ishod.<sup>12</sup>

Vrijednosti brzina ranog dijastoličkog punjenja LK nisu se statistički značajno razlikovale u obje ispitivane skupine ( $p > 0,05$ ), ali je ova vrijednost bila niža u odnosu na srednju vrijednost brzine ranog dijastoličkog punjenja LK kod zdravih osoba. Tijekom akutne ishemijske vrijednost brzine ranog dijastoličkog punjenja je snižena.<sup>13</sup> Vrijednost brzine atrijske faze dijastoličkog punjenja LK je slična vrijednosti kao kod zdravih osoba. Vrijednost odnosa rane i atrijske faze dijastoličkog punjenja LK je ostala nepromijenjena i nije se statistički značajno razlikovala između dvije ispitivane skupine ( $p > 0,05$ ). Schannwell i suradnici su dokazali sniženje maksimalne brzine rane i kasne faze dijastoličkog punjenja klijetke u bolesnika sa stabilnom anginom pectoris kojima su ergometrijskim testiranjem izazivali akutnu ishemijsku.<sup>14</sup> Odnos brzine rane i kasne faze dijastoličkog punjenja klijetke se održavao konstantnim u akutnoj ishemijskoj.

Poremećaj u dijastoličkoj funkciji srca javlja se u ranoj fazi bolesti, izazvan smetnjama u prilagodljivosti LK, najčešće ranije od kliničke manifestacije bolesti i sistoličke disfunkcije LK.<sup>15</sup> Ishemijska bolest srca najčešće dovodi do dijastoličke disfunkcije LK, kao i u bolesnika s arterijskom hipertenzijom. Starenjem se razvija krutost arterijskog sustava što uzrokuje produženu relaksaciju.<sup>16</sup>

Očuvana sistolička funkcija srca uz poremećaj dijastoličke funkcije susreće se kod ishemijske bolesti srca, vo-

The incidence of cardiovascular diseases is about three times higher in men.<sup>6</sup> Out of currently known cardiovascular risk factors the following are recorded: hypertension, diabetes, smoking, hyperlipoproteinemia, obesity and positive family history. Smoking is a significant risk factor since it greatly increases the possibility of occurrence of cardiovascular diseases in men.<sup>7</sup> In menopause in females, smaller amounts of estrogen are secreted. Consequentially, there occurs lipid metabolism disorder, thus increasing the risk for developing cardiovascular diseases.<sup>8</sup> The most significant risk factors for occurrence of AMI are smoking and lipid abnormalities, which can be seen in the relation between apolipoproteins A and B (ApoB/ApoA1). The following significant risk factors are diabetes and hypertension, as shown by this study. Diabetes increases the risk of AMI development, because it increases the incidence of progression of atherosclerosis. Systolic and diastolic hypertension is associated with an increased risk of AMI development and a positive family history (presence of ischemic heart disease in first-degree relatives of affected individuals before the age of 55 in men and before the age of 65 for women). The relative importance of each risk factor varies and is mostly related to its prevalence. Hyperlipoproteinemia, smoking and psychosocial factors are the most important risk factors worldwide. The above-mentioned factors when associated have the cumulative effect and thus significantly increase the risk of development of AMI.<sup>9,10</sup>

Diastolic dysfunction is an early indicator of the disease in the affected heart and usually precedes systolic dysfunction. The primary diastolic dysfunction implies normal LV systolic function. Doppler echocardiography is a very sensitive method in proving normal and disturbed heart functioning during diastole.<sup>11</sup> Measurements of diastolic function by using LV Doppler echocardiography method can predict clinical outcome.<sup>12</sup>

The value of velocity of early diastolic filling of LV was not statistically significantly different in the both groups ( $p > 0,05$ ), but this value was lower compared to the average value of the velocity of the early diastolic filling of LV in healthy persons. During acute ischemia, the value of velocity of early diastolic filling is lowered.<sup>13</sup> The value of velocity of atrial phase of LV diastolic filling is the similar value as in healthy persons. The value of the relation between the early and atrial phase of diastolic filling of LV remained unchanged and was not statistically significantly different between the two groups ( $p > 0,05$ ). Schannwell et al. have proved the reduction of maximal velocity of the early and late phase of ventricular diastolic filling in patients with stable angina pectoris to whom acute ischemia was caused by exercise tests.<sup>14</sup> The ratio between velocity of early and late phase of ventricular diastolic filling remained constant during acute ischemia.

The disorder in diastolic heart function occurs in the early phase of the disease, caused by LV compliance disorder, often prior to clinical manifestations of the disease and LV systolic dysfunction.<sup>15</sup> Ischemic heart disease usually leads to LV diastolic dysfunction and in hypertensive patients. Aging causes the development of arterial system stiffness which causes the prolonged relaxation.<sup>16</sup>

Preserved systolic heart function associated with abnormal diastolic function is found in ischemic heart disease, volume overload, cardiomyopathy and other cardiac



lumnog opterećenja, kardiomiopatija i drugih kardioloških bolesti.<sup>17</sup> *Chow i suradnici* smatraju da trećina srčane insuficijencije nastaje radi dijasoličke disfunkcije, trećina radi sistoličke disfunkcije te trećina radi sistoličko-dijasoličke disfunkcije srca.<sup>18</sup>

Deceleracijsko vrijeme je ostalo nepromijenjeno u obje ispitivane skupine i nije se statistički značajno razlikovalo ( $p > 0,05$ ), kao niti vrijeme izovolumetrijske relaksacije (IVRT) ( $p > 0,05$ ). *Pennock i suradnici* analizirajući zbivanja jedan sat nakon nastanka AIM nisu uočili promjene u vremenu akceleracije, deceleracije te vremenu izovolumetrijske relaksacije.<sup>19</sup>

U maksimalnoj brzini sistoličkog protoka plućnih vena nađena je statistički značajna razlika ( $p < 0,05$ ) između ispitivanih skupina. U skupini s anteroseptalnim AIM brzina je iznosila  $0,48 \pm 0,10$ , a u skupini s inferiornim AIM je iznosila  $0,57 \pm 0,14$ . Maksimalna brzina dijasoličkog protoka plućnih vena u prvoj skupini iznosila je  $0,37 \pm 0,09$ , a u drugoj skupini iznosila je  $0,43 \pm 0,16$ .

Odnos maksimalne brzine sistoličkog i dijasoličkog protoka plućnih vena je nešto veći nego kod zdravih osoba. AIM dovodi do promjena u protoku plućnih vena. Inicijalno maksimalna brzina sistoličkog protoka plućnih vena ostaje ista, a u kasnijem tijeku razvoja AIM opaža se redukcija maksimalne brzine sistoličkog protoka plućnih vena. U samoj početnoj fazi AIM opaža se redukcija maksimalne brzine dijasoličkog protoka plućnih vena, koja se održava i kasnije tokom razvoja bolesti. Uslijed ovih promjena dolazi do povećavanja odnosa između maksimalne brzine sistoličkog i dijasoličkog protoka plućnih vena.<sup>19</sup> *Poulsen i suradnici* također opisuju redukciju maksimalne brzine E i A vala te S i D vala u ranoj fazi AIM.<sup>20</sup> Podjednaka redukcija maksimalne brzine E i A vala održava odnos maksimalne brzine ranog i kasnog dijasoličkog punjenja LK. Izraženija redukcija dijasoličkog protoka u odnosu na sistolički protok plućnih vena dovodi do povećanja odnosa sistoličke i dijasoličke komponente protoka plućnih vena. U AIM registriraju se niže brzine ranog pokreta mitralnog prstena u odnosu na zdrave osobe. Redukcija brzine ranog pokreta mitralnog prstena je izraženija u bolesnika s anteroseptalnim nego u onih s inferiornim AIM.<sup>21</sup>

Prilikom usporedbe učestalosti očuvane dijasoličke funkcije LK između obje skupine ispitanika registriran je veći broj ispitanika ( $n=12$ ) u skupine s inferiornim u odnosu na anteroseptalni AIM ( $n=6$ ), no statistički značajna razlika između skupina nije bila registrirana ( $p > 0,05$ ).

U obje ispitivane skupine registriran je isti broj ispitanika s dijasoličkom disfunkcijom tipa poremećaja relaksacije LK ( $n=19$ ). Prva skupina ispitanika kod kojih se manifestirao poremećaj relaksacije LK je nešto veća u odnosu na drugu skupinu promatrajući ukupan broj ispitanika, ali nije registrirana statistički značajna razlika između obje skupine ( $p > 0,05$ ). Također, u obje ispitivane skupine s dijasoličkom disfunkcijom tipa poremećaja restrikcije LK registriran je isti broj ispitanika ( $n=2$ ), a razlika nije bila statistički značajna ( $p > 0,05$ ).

U prvim danima AIM opisuje se smanjena rastegljivost LK. Pacijenti sa dijasoličkom disfunkcijom tipa restrikcije imaju povećane tlakove punjenja LK.<sup>20</sup>

Analizom rezultata zapaža se da u bolesnika s AIM dominira dijasolička disfunkcija tipa poremećaja relaksacije

diseases.<sup>17</sup> *Chow et al.* believe that one third of cardiac insufficiency occurs as a consequence of diastolic dysfunction, one third occurs as a consequence of systolic dysfunction and one third occurs as a consequence of the systolic-diastolic heart dysfunction.<sup>18</sup>

Deceleration time remained unchanged in the both groups of patients and was not statistically significantly different ( $p > 0,05$ ) and the time of isovolumic relaxation time (IVRT) was not significantly different ( $p > 0,05$ ). *Pennock et al.* have after having analyzed the events one hour after the occurrence of AMI does not observed changes in the time of acceleration, deceleration and isovolumic relaxation time.<sup>19</sup>

In the maximum velocity of systolic pulmonary venous flow, a statistically significant difference was recorded ( $p < 0,05$ ) among the groups. In the group with anteroseptal AMI, the velocity amounted to  $0,48 \pm 0,10$ , while in the group with inferior AMI it amounted to  $0,57 \pm 0,14$ . The maximum velocity of diastolic pulmonary venous flow in the first group was  $0,37 \pm 0,09$ , while in the second group it was  $0,43 \pm 0,16$ .

The ratio of maximum velocity of systolic and diastolic pulmonary venous flow is slightly higher than in healthy persons. AIM leads to changes in the pulmonary venous flow. The initial maximum velocity of systolic pulmonary venous flow remains the same, and later during the development of AMI observe the reduction of the maximum velocity of systolic pulmonary venous flow. In the initial phase of AMI observe the reduction of the maximum velocity of diastolic pulmonary venous flow, which is maintained later during the development of the disease. These changes cause an increase in the relation between the maximum systolic pulmonary venous flow velocity and diastolic pulmonary venous flow velocity.<sup>19</sup> *Poulsen et al.* also describe the reduction of the maximum E and A wave velocity and S and D wave in the early AMI phase.<sup>20</sup> An equal reduction of the maximum velocity of E and A wave reflects the ratio between the maximum velocity of early and late diastolic filling of LV. More pronounced reduction of diastolic flow compared to systolic pulmonary venous flow leads to an increase in relations between systolic and diastolic component of pulmonary venous flow. Lower velocities of the early mitral ring motion are recorded in AIM in comparison to healthy persons. The reduction of the early mitral ring motion velocity is more pronounced in patients with anteroseptal than in those with inferior AMI.<sup>21</sup>

When comparing the frequency of normal diastolic function of LV between the both groups, a higher number of patients ( $n=12$ ) was recorded in the groups with inferior compared to the group with anteroseptal AMI ( $n=6$ ), but statistically a significant difference between the groups was not recorded ( $p > 0,05$ ).

In the both groups, the same number of patients with LV diastolic dysfunction of relaxation disorder type ( $n=19$ ) was recorded. The first group of patients in whom the LV relaxation disorder is manifested is slightly larger than the other group considering the total number of patients, but the statistically significant difference between the both groups ( $p > 0,05$ ) is not recorded. Also, in the both groups with diastolic dysfunction of LV restriction type, the same number of patients ( $n=2$ ) was recorded, and the difference was not statistically significant ( $p > 0,05$ ).

During the first days of AMI, the reduced LV compliance is described. Patients with diastolic dysfunction of restriction type have elevated pressures of filling LV.<sup>20</sup>





LK. U ispitivanoj skupini bolesnika s anteroseptalnim AIM dijastolička disfunkcija tipa poremećaja relaksacije LK je dominantna, odnosno utvrđena je statistički značajna razlika u odnosu na očuvanu dijastoličku funkciju i na dijastoličku disfunkciju tipa poremećaja restrikcije LK.

Rastegljivost LK, kao i relaksacija miokarda zahvaćene su ishemijskom miokarda, ali predominantna dijastolička abnormalnost je poremećaj relaksacije. Pacijenti s dijastoličkom disfunkcijom tipa poremećaja relaksacije LK često su asimptomatski i imaju normalne ili blago povišene tlakove punjenja LK. Dijastolička disfunkcija LK prisutna je u ranoj fazi novonastalog AIM<sup>20</sup>, a disfunkcija tipa poremećaja relaksacije česta je pojava, kako u kroničnom tako i u AIM.<sup>13</sup>

U ispitivanoj skupini bolesnika registrirani su svi poremećaji dijastoličke funkcije LK (poremećaj relaksacije i restrikcije te pseudonormalizacija).

Pseudonormalizacija predstavlja fenomen koji skriva stvarnu sliku o poremećaju dijastoličke funkcije srca. Fenomen pseudonormalizacije može imati izgled nalaza kao kod zdrave osobe i kao poremećaj dijastoličke funkcije tipa restrikcije LK. Drugim riječima, prikriva poremećaj relaksacije odnosno poremećaj restrikcije. S jednostavnim Valsalvinim pokusom, koji je učinjen kod svakog ispitanika, demaskiran je fenomen pseudonormalizacije. Ukoliko fenomen pseudonormalizacije zadržava nalaz kao kod poremećaja dijastoličke funkcije tipa restrikcije radi se o teškoj ireverzibilnoj dijastoličkoj disfunkciji. Na Valsalvin pokus pseudonormalizacija može prijeći i u poremećaj relaksacije dijastoličke funkcije LK sa ili bez povećanog endodijastoličkog tlaka LK. Tkivna Doppler tehnika također omogućuje demaskiranje fenomena pseudonormalizacije.

Poremećaj relaksacije dijastoličke funkcije LK s povećanim endodijastoličkim tlakom LK registriran je u 9 ispitanika i to u 5 ispitanika u skupini s inferiornim i 4 ispitanika u skupini s anteroseptalnim AIM, a statistički značajna razlika nije registrirana ( $p > 0,05$ ). Tokom akutne faze infarkta miokarda, ako endodijastolički tlak LK i tlak u lijevoj pretklijetki ostanu u normalnim granicama, ishemijska miokarda može rezultirati u produženju vremena izovolumetrijske kontrakcije. Ali ako je tlak u lijevom atriju povišen, neće nastupiti produženje vremena izovolumetrijske kontrakcije, odnosno ostat će u referentnim vrijednostima kao kod zdravih osoba ili će biti skraćeno.<sup>22</sup> U bolesnika s AIM i očuvanom sistoličkom funkcijom LK, razvoj plućne kongestije uzrokovan dijastoličkom disfunkcijom i povećanim endodijastoličkim tlakom LK predstavlja indikator loše prognoze.<sup>23</sup> Određivanje dijastoličke funkcije ima veći prediktivni značaj nego kliničke varijable<sup>24</sup>, a može pomoći u razlikovanju pacijenata s AIM od pacijenata sa sindromom akutnog baloniranja srca.<sup>25</sup>

## Zaključak

U AIM, kako anteroseptalne tako i inferiorne stijenke promijenjene su varijable dijastoličke funkcije, odnosno prisutna su sva tri stupnja dijastoličke disfunkcije LK. Dominira dijastolička disfunkcija tipa poremećaja relaksacije miokarda LK.

Kod AIM anteroseptalne stijenke češće je prisutna dijastolička disfunkcija tipa poremećaja relaksacije miokarda

By analyzing the results, we observe that in patients with AMI, LV diastolic dysfunction of the relaxation type prevails. In the tested group of patients with anteroseptal AMI, diastolic dysfunction of the relaxation disorder type prevails, that is, a statistically significant difference compared to the normal diastolic function and diastolic dysfunction of the restriction disorder type is determined.

LV compliance and myocardial relaxation are affected by myocardial ischemia, but the predominant diastolic abnormality is a relaxation disorder. Patients with LV diastolic dysfunction of relaxation disorder type are often asymptomatic and have normal or slightly elevated LV filling pressures. LV diastolic dysfunction is present in the early stage of newly occurred AMI<sup>20</sup>, while the dysfunction of relaxation disorder type is a common phenomenon, not only in chronic but also in AMI.<sup>13</sup>

In the examined group of patients, all types of LV diastolic dysfunction are recorded (relaxation and restriction disorder as well as pseudonormalisation).

Pseudonormalisation is a phenomenon that conceals the real condition of the abnormal diastolic function disorder. The pseudonormalisation phenomenon may take an appearance as in a healthy person and as the LV diastolic function disorder of restriction type. In other words, it conceals the relaxation disorder or restriction disorder. With the simple Valsalva maneuver which was done in every patient, the pseudonormalisation phenomenon was unmasked. If the pseudonormalisation phenomenon retains the finding as in the diastolic function disorder of restriction type, severe irreversible diastolic dysfunction is in question. On the Valsalva's test, pseudonormalisation can change into relaxation disorder of LV diastolic function with or without elevated LV end-diastolic pressure. Tissue Doppler technique also allows unmasking of the pseudonormalisation phenomenon.

Relaxation disorder of LV diastolic function with elevated end-diastolic pressure was recorded in 9 patients, namely in 5 in the group with inferior and 4 examinees in the group with anteroseptal AMI, while statistically significant difference was not recorded ( $p > 0,05$ ). During the acute phase of myocardial infarction, if the LV end-diastolic pressure and the left atrial pressure remain within normal limits, myocardial ischemia can result in the prolongation of isovolumic contraction time. But if the left atrial pressure is elevated, no prolongation of isovolumic contraction time will occur, that is, it will remain within the reference values as in healthy persons or it will be shortened.<sup>22</sup> In AMI patients with preserved systolic function, the development of pulmonary congestion caused by diastolic dysfunction and elevated LV end-diastolic pressure is an indicator of worse prognosis.<sup>23</sup> Determination of the diastolic function has greater predictive importance than clinical variables<sup>24</sup>, and it may help to distinguish patients with AMI from the patients with the acute apical ballooning syndrome.<sup>25</sup>

## Conclusion

In the both anteroseptal and inferior AMI, the variables of diastolic function are changed, that is, all three degrees of LV diastolic dysfunction are present. Diastolic dysfunction of myocardial relaxation disorder type prevails.



LK, odnosno postoji dobra korelacija s infarciranom zonom u odnosu na inferiornu lokalizaciju AIM.

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