„Ovidius” University Constanţa

POSTINFARCTION LEFT VENTRICULAR ANEURYSM - CLINICAL, ECHOCARDIOGRAPHIC AND ANGIOGRAPHIC FEATURES

PhD thesis

Abstract

Scientific coordinator: Prof Victoria Ulmeanu

PhD student: Dan Cosmin Călin

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Table of Contents

Chapter I. Objectives……………………..1

Chapter II. Methods………………..2

Chapter III. Analysis of left ventricular aneurysm determinants in patients with myocardial infarction

1. Results…………………...………………………………………………………………...….5

2. Conclusions…………………………………………………………………….………..13

Chapter IV. Analysis of the echocardiographic features of patients with left ventricular aneurysm

1. Results……………………..………………………………………………………..……..14

2. Conclusions……………………………………………………………………….…..22

Chapter V. Limitations...23

Chapter VI. Final conclusions...25

Refferences...27

Chapter I

Objectives

Left ventricular aneurysm is an important mechanical complication of acute myocardial infarction, with a series of complications associated with a decreased long term prognosis[1,2]. Data concerning the clinical and angiographic factors associated with the presence of left ventricular aneurysm in patients with myocardial infarction are scarce and these data come from studies conducted over 10 years ago, in different circumstances of evaluation and treatment[3-7].

Given that data regarding the characteristics of patients with left ventricular aneurysm is controversial, we aimed to analyze the impact of clinical data related to functional status and cardiovascular risk factors and angiographic factors (related to the distribution and type of coronary lesions) on the occurrence of left ventricular aneurysm in patients with ST-segment elevation myocardial infarction. The analysis of acute myocardial infarction treatment on left ventricular aneurysm formation was another aim of our study, as this was not studied under the current treatment circumstances (including the pharmacological and interventional reperfusion therapy). We started from the hypothesis that, unlike patients who does not develop left ventricular aneurysm, patients with left ventricular aneurysm had more frequently an occlusion of the infarct related artery and there are often significant coronary lesions in the non-infarct related arteries. We tested this hypothesis in a large population of consecutive patients in their first year after an acute ST-segment elevation myocardial infarction investigated by coronary angiography in a tertiary cardiology center.

Echocardiography remains the investigation of choice for the evaluation of left ventricular function. Information obtained by echocardiography have both diagnostic and prognostic role and is an useful tool in the therapeutic decision regarding the indication and type of surgery in patients with left ventricular aneurysm. Knowing the influence of left ventricular aneurysm presence on a series of new left ventricular function parameters, and the relationship that exists between them and classical echo parameters of left ventricular systolic and diastolic function may provide new information about the pathophysiology of heart failure occurance in patients with left ventricular aneurysm and offer the premises of research on their prognostic role in this population.

Under these circumstances, the second objective of our study was to analyze the additional role of new echocardiographic parameters regarding left ventricular geometry and function in patients with left ventricular aneurysm. We conducted a prospective study involving patients with anterior left ventricular aneurysm who were evaluated by echocardiography in an advanced echocardiography laboratory, where they were subject to a comprehensive echocardiographic evaluation of left ventricular function using the advantages of 3D, tissue Doppler and speckle tracking echocardiography. These patients were analyzed in comparison with a control group of patients with a history of previous myocardial infarction who had anterior wall akinesia, in the same territory.

Study objectives

I. To analyze the clinical and angiographic characteristics of patients with left ventricular aneurysm in a large population of consecutive patients with a history of ST-segment elevation myocardial infarction in the first year of evolution – retrospective study

- The comparative assessment of clinical parameters (related to functional status and classic cardiovascular risk factors) and angiographic features (related to the distribution and extent of coronary lesions) in patients with left ventricular aneurysm and those who did not develop this complication
- The study of clinical and angiographic determinants of left ventricular aneurysm formation after myocardial infarction

II. The analysis of new echocardiographic parameters of left ventricular geometry and function in patients with anterior left ventricular aneurysm – prospective study

- The comparative analysis of echocardiographic features in patients with anterior left ventricular aneurysm and in patients with a previous anterior myocardial infarction without ventricular aneurysm (with myocardial akinesia in the infarcted territory)
- The analysis of the feasibility of new echocardiographic techniques of left ventricular function in patients with left ventricular aneurysm
- The study of the impact of left ventricular aneurysm on global longitudinal, circumferential and radial left ventricular strain and left ventricular torsion.

Chapter II

Methods

This paper includes the results of two studies, one study in which the clinical and angiographic determinants of left ventricular aneurysm presence were retrospectively analyzed in a large population of patients with a history of ST elevation myocardial infarction and the other study in which we prospectively analyzed a group of patients with left ventricular aneurysm in which a series of new echocardiographic parameters of left ventricular geometry and function were studied.

Retrospective study protocol

We retrospectively analyzed a group of patients with documented ST elevation myocardial infarction, in their first year after the acute event, consecutively enrolled according to the eligibility criteria listed below.

Including criteria

- documented history of ST segment elevation acute myocardial infarction within a range between 30 and 360 days from the acute event,

- angiographic data availability during present hospitalization.

Excluding criteria

- patients whose clinical, echocardiographic and angiographic data were not available or uncertain, non documented acute myocardial infarction.

After applying the inclusion and exclusion criteria, the final group consisted of 285 patients in whom we analyzed clinical parameters: age, sex, common cardiovascular risk factors and functional status at admission (NYHA class, presence or absence of angina pectoris), echocardiographic and angiographic parameters (number, distribution and extent of coronary lesions) as well as data related to the treatment of acute myocardial infarction and in the first month after its occurrence.

The diagnosis of left ventricular aneurysm was established in all cases based on echocardiographic criteria by treating physicians. After analyzing the data contained in the observation charts of the included patients two groups were formed: group 1 comprised 106 patients with left ventricular aneurysm and group 2 consisted of 179 patients without left ventricular aneurysm. These groups were comparatively analyzed in terms of clinical, angiographic factors and related therapy, in order to identify independent determinants of the presence of left ventricular aneurysm in patients with a history of myocardial infarction. For a better characterization of patients with left ventricular aneurysm we have also analyzed several echocardiographic parameters that were available for all patients included in the study.

Prospective study protocol

We conducted a prospective study in the Department of Cardiology of "Prof. Dr. CC Iliescu" Emergency Institute for Cardiovascular Diseases in which we enrolled all consecutive patients with a diagnosis of old myocardial infarction presented for an echocardiographic assessment in the Euroecolab Echocardiography Laboratory of UMF Carol Davila between 2011-2012.

Including criteria: a documented history of ST segment elevation anterior myocardial infarction, with wall motion anomalies (akinesia, dyskinesia, or ventricular aneurysm) in the infarcted territory (at the level of left ventricular apex, anterior or anterolateral wall).

Exclusion criteria: difficult echocardiographic window, absence of sinus rhythm, presence of conduction abnormalities, left ventricular wall motion anomalies in the inferior territory or significant valvular lesions: more than mild aortic stenosis or aortic regurgitation, mitral stenosis of any degree, severe mitral regurgitation.

Left ventricular aneurysm was defined as a well-demarcated area with paradoxical systolic and diastolic motion located in the left ventricular wall. Were included only patients who had dyskinesia in at least one segment within the anterior descending artery territory.

The control group consisted of patients with similar age and sex, with a history of anterior myocardial infarction and the same inclusion and exclusion criteria, which presented akinesia in the infarcted territory - in the left ventricular apex and adjacent segments, similar to location of the left ventricular aneurysm in patients included in the study group.

The acquisition of echocardiographic images for all patients enrolled in the study was performed using a Vivid 7 Dimension or a Vivid E9 machine (GE Healthcare).

The acquisition protocol included standard minimal image acquisition protocol for transthoracic echocardiography recommended by the European Association of Echocardiography[8] and the following complementary sections:

- short axis view at the base of the left ventricle (at the level of the mitral valve) and the left ventricular apex (distally to the papillary muscles). These images were acquired with a frame rate of 60-100 fps and were then used for off-line evaluation of circumferential and radial basal strain parameters, basal and apical left ventricular rotation and left ventricular torsion
- apical 4 chamber, 3 chamber and 2 chamber views, centered on the left ventricle, used for the off-line measurement of left ventricular longitudinal strain parameters by speckle tracking echocardiography.

For patients with left ventricular aneurysm three dimensional echocardiographic images were aquired according to existing recommendations[9] in order to measure left ventricular volumes and ejection fraction.

All echocardiographic parameters included in the standard echocardiographic examination including maximum systolic (S') and diastolic (early, E' and late, A') velocities obtained by pulsed wave tissue Doppler at the level of the mitral annulus at the septal and lateral levels and wall motion score index were measured according to the standards of the American Society of Echocardiography.[10] In patients with left ventricular aneurysm left ventricular volumes were measured and left ventricular ejection fraction was calculated by 3D echocardiography in those patients in whom this method was feasible.

The acquired images were digitally stored and subsequently analyzed off-line using a dedicated software (EchoPac BT 10, GE Medical Systems) that enables the measurement of myocardial deformation parameters, including rotation and torsion by speckle tracking echocardiography (two-dimensional strain). The off-line analysis of longitudinal, radial, and circumferential strain and rotation was performed for all patients who had adequate two dimensional images in all the three apical sections and at the base and apex of the left ventricle.

Statistics

Statistical analysis. Continue variables are expressed as mean value ± standard deviation and discontinue variables as number (percent). Student t-test was used for mean values comparison between groups in case of a normal dispersion. In order to prove the effect of a certain event, parametric dispersional analysis tests ANOVA and non parametric correlation tests were used. The comparison between two dependent groups was made using parametric t-test or its non parametric equivalent – Wilcoxon signed rank as required.

Linear regression analysis was used and Pearson method was applied for correlation coefficients calculation. In order to study the concomitant contribution of multiple factors in the occurence of an event, multiple linear or logistic regression were used. All statistical analyses were performed using SPSS 14.0 software for Windows (SPSS, Inc., Chicago, Illinois). A two-sided p-value of 0.05 was considered significant.

Informed consent

All patients received information about the study protocol and informed consent were required. Evaluation in this study did not interfere with the assessment protocol or the therapeutic decision that were made by the treating physicians. During the present study all rules have been complied with good medical practice (Good Medical Practice) and the principles of the Declaration of Helsinki on medical ethics of clinical research.

Chapter III

Determinants of left ventricular aneurysm formation in patients with acute myocardial infarction

1. Results

The final study group consisted of 285 patients (age 32-85 years, mean 60.3 ± 10.7 years, 77% men) with a documented history of ST elevation myocardial infarction in the first year of evolution, investigated by coronary angiography in our clinic.

After the echocardiographic evaluation performed in our clinic 106 patients (age 62 ± 10 years, 87 males) out of 285 patients had a left ventricular aneurysm. These patients constituted group 1. The remaining 179 patients (age 59 ± 11 years, 133 men) formed the control group (group 2). Patients with left ventricular aneurysm were significantly older than those without ventricular aneurysm (p = 0.02). Distribution by age decade compared in the two studied groups is shown in Figure 1.

Between the two groups there was no significant difference regarding the sex of included patients (p = 0.2).

In the group of patients with left ventricular aneurysm the majority of patients had aneurysms located in the anterior territory (93 patients, 87%), 11 patients had inferior aneurysms and 2 patients had both anterior and inferior aneurysms. Unlike patients with left ventricular aneurysm in the group of patients without left ventricular aneurysm the proportion of patients with anterior myocardial infarction was similar to that of patients with inferior location of myocardial infarction (44% vs. 45%).

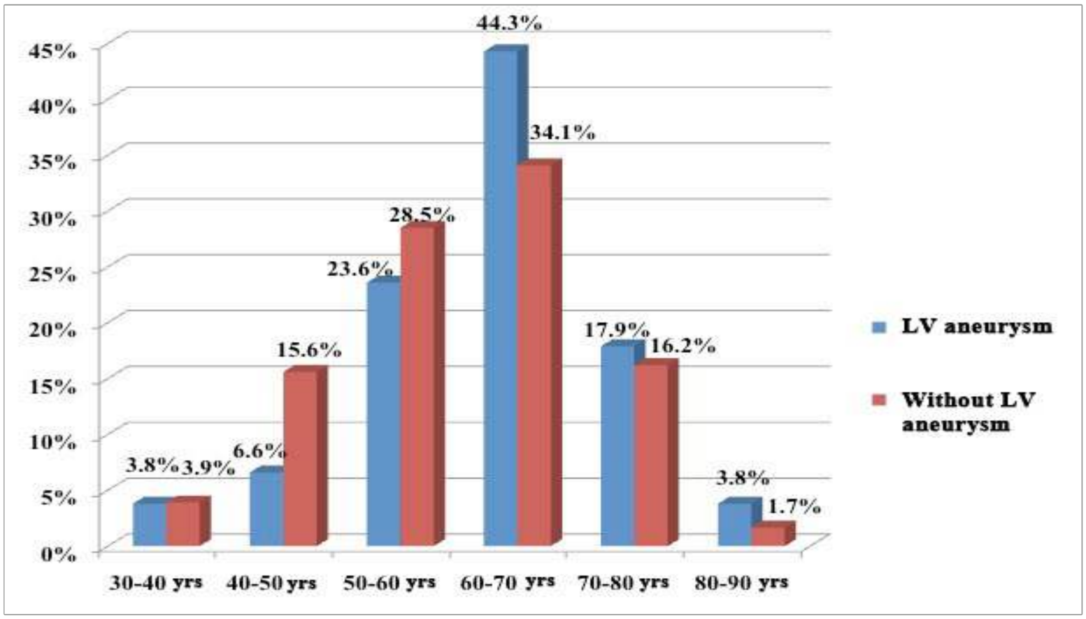

Chart 1. Age distribution in patients with and without left ventricular aneurysm

Thirteen patients had two documented episodes of ST elevation myocardial infarction in the same territory (4 in the anterior territory and 9 in the inferior territory) and 6 patients had myocardial infarction in both territories. Thus, among the 175 patients with a history of anterior myocardial infarction included in the final analysis, 52% had a left ventricular aneurysm compared with only 10% of patients with inferior myocardial infarction, confirming that the anterior location myocardial infarction is associated with a higher risk of ventricular aneurysm formation. This study was conducted in a tertiary cardiology clinic, in a highly selected population, which explains the high proportion of patients with left ventricular aneurysm observed among patients with anterior myocardial infarction.

Regarding the symptoms presented at admission, most patients included in the study were symptomatic, only 4 patients with left ventricular aneurysm and 17 patients without aneurysms were asymptomatic at the time of clinical assessment ($p = 0.07$). Dominant symptoms were dyspnea of various degrees, patients with left ventricular aneurysm being in a more advanced NYHA class at admission compared to those without left ventricular aneurysm (2.2 ± 0.7 to 1.86 ± 0.6 , $p < 0.001$). A similar proportion of patients in both groups had angina on admission (46% in group 1 versus 43% in group 2, $p = 0.6$).

Cardiovascular risk factors analysis

The comparative analysis of cardiovascular risk factors in the two studied groups is shown in Table 1. It is noted that between the two studied groups there were no significant differences regarding the prevalence of hypertension, dyslipidemia, obesity or diabetes, however we noticed a significantly higher prevalence of smoking among patients without left ventricular aneurysm (p = 0.01).

Table 1. Prevalence of cardiovascular risk factors in both study groups

	Group 1 (n=106)	Group 2 (n=179)	p
Smoking	51 (48%)	112 (63%)	**0.01**
Diabetes	36 (34%)	64 (36%)	0.7
Dyslipidemia	99 (93%)	162 (91%)	0.4
Obesity	42 (40%)	57 (32%)	0.2
HTN	89 (84%)	147 (82%)	0.7

HTN, arterial hypertension

Echocardiographic parameters analysis

We comparatively analyzed the following echocardiographic parameters in both groups of patients: linear dimensions of the left ventricle, anteroposterior diameter of the left atrium, left ventricular ejection fraction, presence and degree of mitral regurgitation.

The impact of left ventricular aneurysm on left ventricular structure and function is evident, its consequences being the statistically significant changes in linear dimensions of the left ventricle and left ventricular ejection fraction (Table 2). Left ventricular diameters were significantly increased and left ventricular shortening fraction and ejection fraction were both significantly reduced in patients with aneurysm compared to patients without aneurysm. Left atrial size was similar in the two studied groups, but the only parameter available for all patients was the anteroposterior diameter of the left atrium, knowing that this is not the first change in case of left atrial dilatation.

A significantly higher percentage of patients with left ventricular aneurysm presented global left ventricular systolic dysfunction, expressed as left ventricular ejection fraction <50% (92.5% vs. 60.1%, p <0.001).

There were no significant differences regarding the presence of mitral regurgitation between the two groups but, however, the severity of mitral regurgitation was significantly higher in patients with left ventricular aneurysm, 58% of them showing moderate and severe mitral regurgitation compared to 39% in the group of patients without left ventricular aneurysm (p = 0.002). In patients with left ventricular aneurysm mitral regurgitation degree was significantly correlated with left ventricular dimensions (r = 0.22, p = 0.02 for left ventricular end diastolic diameter and r = 0.25, p = 0.01 for left ventricular end systolic diameter) and the degree of mitral regurgitation, left ventricular dimensions and left ventricular ejection fraction were all significantly correlated with NYHA functional class (Table 3).

Table 2. Echocardiographic parameters analysis

	Group 1 (n=106)	Group 2 (n=179)	p
LVEDD (mm)	58.7 ± 8.9	54.7 ± 7.2	<0.001
LVESD (mm)	44.9 ± 9.9	39.8 ± 9.1	<0.001
IVS (mm)	10.5 ± 2.0	10.9 ±2.0	0.2
LVPW (mm)	10.6 ± 1.7	10.3 ±1.9	0.2
LA (mm)	40.4 ± 6.9	39.1 ± 7.2	0.1
SF (%)	23.8 ± 8.8	27.9 ±10.1	<0.001
LVEF (%)	38.7 ± 8.5	47.5 ± 9.9	<0.001

LVEDD, left ventricular end diastolic diameter; LVESD, left ventricular end systolic diameter; IVS, interventricular septum; LVPW, left ventricular posterior wall; LA, left atrium; SF, shortening fraction; LVEF, left ventricular ejection fraction.

Functional NYHA class was also significantly correlated with patients' age (r = 0.23, p = 0.02), older patients presenting an advanced degree of heart failure. In multiple regression analysis, age and left ventricular end diastolic diameter were independent predictors of NYHA class in patients with left ventricular aneurysm (B = 0.2, p = 0.04 and B = 0.2, p = 0, 03). There was also a statistically significant correlation between the degree of left ventricular systolic dysfunction (as measured by left ventricular ejection fraction) and age, the elderly presenting an advanced degree of systolic dysfunction (r = -0.29, p = 0.003).

Table 3. Correlations of echocardiographic parameters with NYHA functional class in patients with left ventricular aneurysm (n = 106)

	LVEDD	LVESD	LA	SF	LVEF	MR degree
Clasa NYHA	r=0.24 p=0.02	r=0.32 p=0.03	p=NS	p=NS	r=-0.22 p=0.03	r=0.22 p=0.04

LVEDD, left ventricular end diastolic diameter; LVESD, left ventricular end systolic diameter; LA, left atrium; SF, shortening fraction; LVEF, left ventricular ejection fraction; MR, mitral regurgitation.

Angiographic parameters analysis

Comparative analysis of angiographic characteristics between the two groups showed no statistically significant difference in terms of the number of angiographically significant coronary lesions (p = 0.9). The distribution of coronary lesions for the two groups is illustrated in

Table 4. Patients with and without left ventricular aneurysm showed similar extent of coronary lesions.

Table 4. The distribution of coronary lesions in the two study groups

	Group 1 (n=106)	Group 2 (n=179)	p
No significant coronary lesions (n,%)	**5 (4.7)**	**7 (3.9)**	**0.7**
Single vessel disease (n,%)	**38 (35.8)**	**66 (36.8)**	**0.9**
Left anterior descending artery	32 (84.2)	34 (51.5)	0.001
Right coronary artery	5 (13.2)	23 (34.8)	0.02
Circumflex artery	1 (2.6)	4 (6.1)	0.04
Diagonal artery	0	7 (10.6)	0.3
Marginal artery	0	2 (3.0)	0.3
Two vessel disease (n,%)	**33 (31.1)**	**53 (29.6)**	**0.8**
Three vessel disease (n,%)	**30 (28.3)**	**53 (29.6)**	**0.8**

Although the number of coronary lesions was not significantly different between the two groups, patients with LV aneurysm had an occlusion of the infarct related artery more frequently than those without aneurysm (51% vs. 33%, $p = 0.003$).

There were no significant differences between the two groups regarding coronary lesions in non infarct related arteries. Thus, 60% of patients with left ventricular aneurysm had significant lesions in non infarct related arteries compared to 58% of patients without left ventricular aneurysm ($p = 0.8$). The number of occluded arteries was similar in both groups (18% of patients with left ventricular aneurysm presented occlusions in non infarct related arteries compared with 20% of patients without left ventricular aneurysm, $p = 0.5$).

In the entire study group, the number of significant coronary lesions was significantly correlated with age ($r = 0.2$, $p < 0.001$), presence of hypertension ($r = 0.2$, $p = 0.004$), and ejection fraction and mitral regurgitation degree ($r = -0.2$, $p = 0.005$ for all).

Analysis of parameters related to acute myocardial infarction treatment

Data regarding reperfusion therapy of acute myocardial infarction and therapy applied in the first month after the acute event were comparatively analyzed in the two study groups.

In the entire study group, out of the 285 patients with a documented history of ST elevation acute myocardial infarction, 41% received reperfusion therapy, 78 patients received thrombolytic therapy and in 40 patients a primary angioplasty was performed. Among patients with left ventricular aneurysm, 66% did not receive reperfusion therapy at the time of acute myocardial infarction, compared to 48% in the group of patients without left ventricular aneurysm, a statistically significant difference (p = 0.003). With regard to thrombolytic therapy, there were no significant differences between groups, a similar percentage of patients with and without left ventricular aneurysm receiving fibrinolytic therapy (25% versus 31%, p = 0.3). In contrast, a significantly lower percentage of patients with left ventricular aneurysm were treated by primary percutaneous coronary intervention (7.5% vs. 18.5%, p = 0.01).

The analysis of left ventricular aneurysm formation determinants

In univariate analysis, older age, non-smoking status, anterior descending artery occlusion, conventional treatment of acute myocardial infarction and lack of primary percutaneous coronary intervention were significantly correlated with the presence of left ventricular aneurysm in patients with a history of myocardial infarction (Table 5).

Introducing these parameters in multiple regression analysis in the entire study group, non-smoking status, presence of anterior descending artery occlusion and lack of coronary angioplasty were independently correlated with the presence of left ventricular aneurysm. Anterior descending artery occlusion is most closely correlated with the presence of left ventricular aneurysm in patients with a history of myocardial infarction, with an increase of almost 7 times of the risk of left ventricular aneurysm formation.

Table 5. Independent determinants of left ventricular aneurysm formation in patients with myocardial infarction

	Univariate analysis	Multivariate analysis		
	p	p	B regression coefficient	Odds ratio
Age	0.02	0.35		
Smoking	0.01	0.02	-0.94	0.5
LAD occlusion	<0.001	<0.001	1.81	6.9
Lack of reperfusion therapy	0.003	0.71		
Primary PCI	0.01	0.03	-1.2	0.32

LAD, left anterior descending artery, PCI, percutaneous coronary intervention

Sub-group analysis in patients with anterior myocardial infarction

Given the fact that in the group of patients with left ventricular aneurysm the number of patients with inferior myocardial infarction was significantly lower than among those without left ventricular aneurysm, we performed a separate analysis of patients with a history of anterior myocardial infarction in terms of clinical, echocardiographic and angiographic features. We also excluded patients with reinfarction in the anterior territory. Thus, the final group consisted of 159 patients who had a single documented episode of anterior myocardial infarction, 80 patients with anteroapical left ventricular aneurysm (age 62.2 ± 10.6 years, 66 men) and 79 patients without left ventricular aneurysm (age 57.4 ± 10.9 years, 56 men). Between these two groups there was a significant difference in age (p = 0.005).

Regarding the comparative analysis of cardiovascular risk factors between the two subgroups we did not find any significant differences. Although smoking prevalence in the subgroup of patients without left ventricular aneurysm was higher, this difference did not reach statistical significance (62% versus 48% in the subgroup of patients with left ventricular aneurysm, p = 0.08).

Patients with apical left ventricular aneurysm were in a more advanced NYHA functional class at admission compared with patients without left ventricular aneurysm (2.2 ± 0.8 vs. 1.9 ± 0.6, p = 0.02). Angina pectoris was present on admission in a similar proportion of patients in the two subgroups.

Comparative analysis of echocardiographic parameters between groups showed an increased left ventricular size in patients with aneurysm and the presence of a significant degree of left ventricular systolic dysfunction (Table 6). Patients with left ventricular aneurysm had more severe mitral regurgitation, 56% of them moderate and severe mitral regurgitation compared to 29% in patients without left ventricular aneurysm (p = 0.001).

Table 6. The analysis of echocardiographic parameters in patients with anterior myocardial infarction (n=159)

	Pts with LV aneurysm (n=80)	Pts without LV aneurysm (n=79)	p
LVEDD (mm)	57.5 ± 8.3	54.7 ± 7.8	0.03
LVESD (mm)	43.8 ± 8.7	38.9 ± 10.1	0.002
IVS (mm)	10.6 ± 1.9	10.7 ±1.7	0.8
LVPW (mm)	10.5 ± 1.7	10.3 ±1.6	0.5
LA (mm)	40.4 ± 6.9	38.8 ± 6.1	0.1
SF (%)	23.9 ± 8.2	29.5 ±11.3	0.001
LVEF (%)	38.7 ± 8.1	47.1 ± 10.7	<0.001

LVEDD, left ventricular end diastolic diameter; LVESD, left ventricular end systolic diameter; IVS, interventricular septum; LVPW, left ventricular posterior wall; LA, left atrium; SF, shortening fraction; LVEF, left ventricular ejection fraction.

Between patients with left ventricular aneurysm and those without aneurysm there were no significant differences regarding the distribution of angiographically significant coronary lesions, single vessel, two-vessel and three vessel disease being found in similar proportions in the two groups of patients. The extension of coronary artery disease was similar in both groups but left anterior descending artery occlusion was more common in patients with left ventricular aneurysm (46% vs. 17%), a highly statistically significant result (p <0.001)(Table 7).

Table 7. The degree of left anterior descending artery lesions in pts with anterior myocardial infarction

LAD lesion	Pts with LV aneurysm (n=80)	Pts without LV aneurysm (n=79)	p
No significant lesion	5 (6.3%)	13 (16.5%)	0.04
LAD stenosis < 50%	4 (5%)	0	0.04
LAD stenosis > 50%	34 (42.5%)	52 (65.8%)	0.003
Occlusion	37 (46.3%)	14 (17.7%)	<0.001

LAD, left anterior descending artery

A similar percentage of patients in both groups had significant lesions in non infarct related coronary arteries (55% of patients with left ventricular aneurysm compared with 51% of patients without left ventricular aneurysm, p=0.6). The number of occluded arteries other than LAD was similar in both groups (17.5% of patients with left ventricular aneurysm presented occlusion in other coronary arteries compared with 18.9% of patients without left ventricular aneurysm, p = 0.4).

Regarding the treatment of patients with anterior myocardial infarction at the acute event time, 71% of patients with left ventricular aneurysm were treated conservatively, without the benefit of reperfusion therapy, compared with 43% of patients who subsequently developed left ventricular aneurysm (p <0.001). Between the two groups both fibrinolytic therapy and primary coronary angioplasty were applied in a higher proportion in the subgroup of patients who subsequently developed left ventricular aneurysm than in patients with aneurysms (33% vs. 17% for thrombolytic therapy, p = 0.03 and 21% vs 10%, p = 0.05 for coronary angioplasty).

In multiple regression analysis age, left anterior descending artery occlusion and lack of reperfusion therapy of the acute myocardial infarction were independent determinants of left ventricular aneurysm formation in patients with anterior myocardial infarction (Table 8), left anterior descending artery occlusion being associated with an increase of more than three times of the risk of left ventricular aneurysm in patients with anterior myocardial infarction.

Table 8. Factors correlated to left ventricular aneurysm formation in pts with anterior myocardial infarction

	p	B regression coefficient	Odds ratio
Age	0.049	0.03	1.03
LAD occlusion	0.002	1.21	3.36
Lack of reperfusion therapy	0.03	0.96	2.61

2. Conclusions

Left ventricular aneurysm was diagnosed in one third of patients hospitalized with a diagnosis of ST-segment elevation myocardial infarction within the first year of evolution in a tertiary cardiology clinic.

The presence of left ventricular aneurysm has a negative impact on functional status, left ventricular structure and function, resulting in worsening heart failure, increased left ventricular size and decreased left ventricular ejection fraction.

Age and left ventricular end diastolic diameter were independent predictors of NYHA class in patients with ventricular aneurysm.

Comparative analysis between patients with left ventricular aneurysm and those without left ventricular aneurysm showed no significant difference regarding the number of angiographically significant coronary lesions and the distribution of these lesions.

In the entire study group, non-smoking status, the presence of left anterior descending artery occlusion and lack of primary PCI were independently correlated with the presence of left ventricular aneurysm.

In patients with anterior myocardial infarction left nterior descending artery occlusion and lack of reperfusion therapy were independent determinants of left ventricular aneurysm formation.

Chapter IV

The analysis of echocardiographic features in patients with left ventricular aneurysm

1. Results

Were prospectively analyzed 83 patients with a history of anterior ST elevation myocardial infarction, evaluated by echocardiography in the Echocardiography Laboratory Euroecolab of UMF Carol Davila, 3rd Cardiology Clinic of the Emergency Institute for Cardiovascular Diseases "Prof. Dr. CC Iliescu". Were excluded all patients with a history of inferior myocardial infarction and all patients presenting wall motion anomalies in the inferior or inferolateral territory to screening echocardiography and also all patients with significant valvular lesions. Were selected only patients who had akinesia, dyskinesia, or aneurysm in the infarcted segments (the territory of the left anterior descending artery) and after applying the exclusion criteria two final groups were formed: the first group consisted of 20 patients with anterior left ventricular aneurysm (age 61.8 ± 9.4 years, 11 men) and the second group, the control group consisted of 20 patients with left ventricular wall akinesia with similar location (age 56.5 ± 15.2 years, 15 men). There were no significant differences in age or sex between the two groups ($p = 0.2$ for both).

General characterization of the two study groups

In terms of clinical characteristics between the two groups there were no significant differences in the presence and type of symptoms present at admission. There were no significant differences regarding the presence of smoking, diabetes mellitus and dyslipidemia between the two groups, however patients with left ventricular aneurysm were more frequently obese and had more frequently associated arterial hypertension compared to patients with akinesia in the infarcted territory.

Time interval from the acute anterior myocardial infarction ranged between one and three years, without a statistically significantly difference between the two study groups ($p = 0.07$). There were no significant differences between the two groups regarding the treatment at the time of acute myocardial infarction, similar proportions of both groups being medically treated. Only 2 patients in each study group received primary percutaneous coronary intervention and 4 patients (3 in left ventricular aneurysm group) were treated with thrombolytic therapy.

Comparative analysis of echocardiographic parameters between the two study groups

Parameters of left ventricular geometry and systolic function

In this study we aimed to analyze the echocardiographic features of patients with anterior left ventricular aneurysm compared to patients with a history of anterior myocardial infarction and myocardial akinesia in the infarcted territory. We analyzed the classical echocardiographic parameters of left ventricular geometry and function and new parameters,which were not studied so far in patients with left ventricular aneurysm:

- systolic myocardial velocities obtained by pulsed wave tissue Doppler at the level of the mitral annulus (septal and lateral levels)

- global longitudinal deformation of the left ventricle in 17 segments measured by speckle tracking echocardiography,

- circumferential and radial deformation measured by speckle tracking echocardiography at the level of the left ventricular base,

- apical and basal rotation and left ventricular torsion measured by speckle tracking echocardiography,

- left ventricular ejection fraction calculated by three-dimensional echocardiography in patients with left ventricular aneurysm.

Although only patients with good ultrasound window were enrolled, the analysis of longitudinal myocardial deformation by speckle tracking was not possible for all patients, the presence of a large apical aneurysm in some patients making it difficult to obtain adequate apical sections including all left ventricular segments with a suitable method frame rate (over 60 fps). Two of the 40 patients included in the study had inadequate images for longitudinal myocardial deformation analysis in all the three apical sections.

Three dimensional echocardiography data were available for only 10 of the 20 patients with left ventricular aneurysm included in the final study group for reasons held by the limited availability of this technique in the laboratory and by the feasibility of this method. Modified geometry of the left ventricular apex and difficult ultrasound window were the most frequent causes of inability to perform three-dimensional acquisition in patients with left ventricular aneurysm.

Based on inclusion criteria only patients with left ventricular aneurysm presenting aneurysm affecting the anterior wall, including left ventricular apex and adjacent segments with variable extension to the apical and middle segments of the inferior, anterior and lateral walls and interventricular septum. Patients presenting associated basal wall motion anomalies were not included in the study group.

Linear dimensions of the left ventricle were not significantly different between the two groups (Table 9). Indexed left ventricular volumes (measured by biplane Simpson method from apical 4 chamber and 2 chamber views) were higher in patients with left ventricular aneurysm, but this difference was not statistically significant. Left ventricular mass index was similar in the two groups. Left ventricular volumes measured by three-dimensional echocardiography in patients with left ventricular aneurysm were 181±28 ml for left ventricular end diastolic volume (141-214 ml) and 115±16 ml for left ventricular end systolic volume (95-147 ml) with higher average values than those measured by two-dimensional echocardiography (135±38 ml for end diastolic volume of the left ventricle, 83±28 ml for end systolic volume respectively), confirming the published results.[11]

In patients with akinesia in the infarcted territory the degree of left ventricular dilatation was significantly correlated with infarct age (r=0.62, p=0.009 for indexed left ventricular end systolic volume and r =0.53, p =0.006 for indexed left ventricular systolic volume).

In terms of global left ventricular systolic function, left ventricular ejection fraction calculated by biplane Simpson method was not statistically significant different between the two groups, although it was lower in the group of patients with left ventricular aneurysm (Table 10).

The separate analysis of patients with left ventricular aneurysms larger than 40% of the left ventricle, showed a more pronounced global left ventricular systolic dysfunction in these patients (36.7% versus 43.9% in the group of patients with left ventricular akinesia in infarcted segments, p=0.04). Moreover, left ventricular aneurysm size was significantly correlated with left ventricular ejection fraction (r = -0.5, p =0.04) and wall motion score (r = 0.6, p = 0.004).

Table 9. Left ventricular geometry parameters in the two groups

	Group 1 (aneurysm) (n=20)	Group 2 (akinesia) (n=20)	p
LVEDDi (mm/m^2)	28.8 ± 5.5	29.9 ± 3.9	0.5
LVESDi (mm/m^2)	20.8 ± 5.9	21.9 ± 5.3	0.4
IVS (mm)	11.4 ± 1.7	10.6 ±1.4	0.1
LVPW (mm)	11.3 ± 1.6	10.5 ±1.2	0.06
LVEDVi (ml/m^2)	70.3 ± 22.7	66.1 ± 27.9	0.6
LVESVi (ml/m^2)	43.4 ± 18.9	38.6 ±21.6	0.5
LV mass index (g/m^2)	134.6 ± 38.3	128.9 ± 40.9	0.6

LVEDDi, indexed left ventricular enddiastolic diameter; LVESDi, indexed left ventricular endsystolic diameter; IVS, interventricular septum; LVPW, left ventricular posterior wall; LVEDVi, indexed left ventricular enddiastolic volume; LVESVi, indexed left ventricular endsystolic volume.

Left ventricular ejection fraction measured by Simpson method was significantly correlated with left ventricular ejection fraction measured by ventriculography (r = 0.78, p = 0.008).

In patients in whom left ventricular ejection fraction was measured by three-dimensional echocardiography, the measured values were between 31% and 43%, with an average of 36.1 ± 4.7%, lower than that obtained by the Simpson's method (41.9 ± 8.7%), suggesting a tendency to overestimate global left ventricular function using two-dimensional echocardiography in patients with left ventricular aneurysm.

New parameters of global left ventricular systolic function: systolic myocardial velocities measured by Tissue Doppler at the mitral annulus (both septal and lateral and their average) were measured in all patients included in the study. These parameters were not significantly different between the two groups. Global left ventricular longitudinal deformation was lower in patients with left ventricular aneurysm than in those with akinesia in the infarcted territory (-9.3% to -10.9%), but this difference was not statistically significant (p = 0.1).

Given that longitudinal deformation is positive in aneurysmal segments (these segments are streched in systole) (Figure 1) we considered useful to comparatively assess longitudinal deformation measured only in non-aneurysmal segments, its value being similar in the two groups (Table 10).

In the entire study group there is a strong correlation between global longitudinal deformation of the left ventricle and left ventricular ejection fraction calculated by Simpson method (Figure 2), a decrease in left ventricular longitudinal strain being associated to a decreased left ventricular ejection fraction.

Table 10. Parameters of left ventricular systolic function

	Group 1 (aneurysm) (n=20)	Group 2 (akinesia) (n=20)	p
LVEF (%)	40.1 ± 8.4	43.9 ± 8.8	0.2
SF (%)	28.4 ± 7.3	27.8 ± 9.7	0.8
LVSVi (ml/m^2)	29.2 ± 6.2	29.2 ± 9.6	0.9
WMSI	2.43±0.36	1.91±0.27	<0.001
Sseptal (cm/s)	5.3 ± 1.2	5.3 ±1.3	0.9
Slateral (cm/s)	5.8 ± 1.5	6.1 ± 1.5	0.6
Saverage (cm/s)	5.6 ± 0.8	5.7 ±1.3	0.7
GLS (%)	-9.4±2.5	-10.9±3.2	0.1
LSNI	-13.1±1.9	-13.1±3.2	0.9
CS	-10.2±4.4	-12.5±3.9	0.1
RS	35.7±13.5	25.7±9.4	0.04

LVEF, left ventricular ejection fraction; FS, left ventricular shortening fraction; Sseptal, Slateral, Smediu, systolic myocardial velocities measured by pulsed wave tissue Doppler at the level of the septal and lateral wall and the average value of these parameters; GLS, global longitudinal strain; LSNI, longitudinal strain in noninfarcted segments; WMSI, wall motion score index; CS, circumferential basal strain; RS, radial basal strain.

In the group of patients with left ventricular aneurysm we separately analyzed the correlations of left ventricular global longitudinal deformation, the results of univariate analysis are shown in Table 11. It is noted that in this group there is a significant correlation between global longitudinal deformation of the left ventricle and left ventricular ejection fraction, global longitudinal deformation being also significantly correlated with indexed left ventricular volumes, wall motion score index and the average systolic myocardial velocity obtained by tissue Doppler at the mitral annulus.

An increase in left ventricular volumes in patients with left ventricular aneurysm is associated with a decreased left ventricular global longitudinal strain. In the entire study group there was a significant relationship between NYHA functional class and left ventricular global longitudinal deformation, a reduced deformation being associated with an advanced NYHA class ($r = 0.4$, $p = 0.04$).

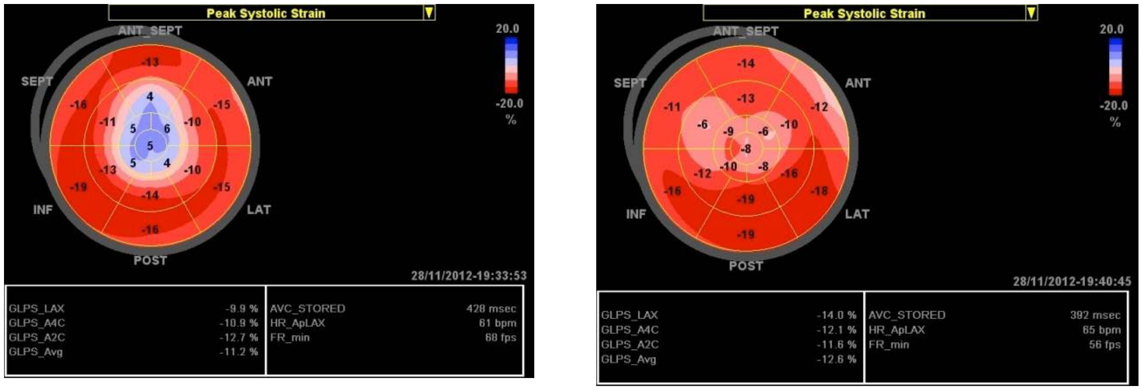

Figure 1. Bull's eye view of the global longitudinal strain measured in 17 segments in a patient with apical left ventricular aneurysm (A) and in a patient with apical akinesia (B). It is noted that in the first case dyskinetic segments have positive values of longitudinal deformation (in blue) while in the second case the myocardial fiber shortening is lower at the apex - longitudinal deformation with negative values lower than at the basal level.

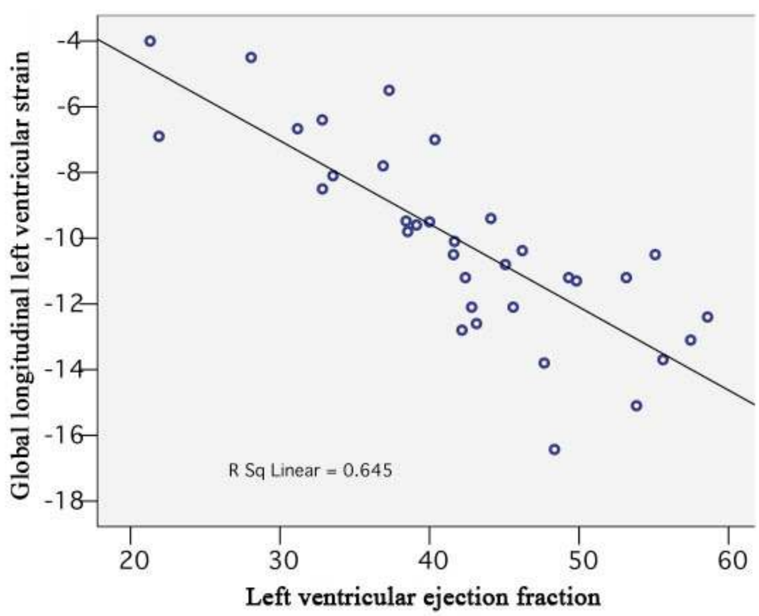

Chart 2. The correlation between global left ventricular longitudinal deformation and left ventricular ejection fraction measured by biplane Simpson method

Table 11. Correlations of global longitudinal strain with parameters of left ventricular geometry and function in patients with left ventricular aneurysm

	LVEDVi	LVESVi	LV mass	Size of LV aneurysm	LVEF	WMSI	Saverage
GLS	r=0.68	r=0.77	r=0.14	r=0.45	r=-0.86	r=0.74	r=0.62
	p=0.003	p<0.001	p=0.6	p=0.07	p<0.001	p=0.001	p=0.02

LVEF, left ventricular ejection fraction;Saverage, the average value of systolic myocardial velocities measured by pulsed wave tissue Doppler at the level of the septal and lateral wall; GLS, global longitudinal strain; WMSI, wall motion score index.

An important role in the pathophysiology of left ventricular systolic dysfunction after a myocardial infarction is played by the function of noninfarcted segments and the transition zone between infarcted and non infarcted myocardium. In this context we included in our study an evaluation of regional function of the left ventricular segments outside the infarcted area, analyzing their longitudinal, circumferential and radial function.

Radial and circumferential deformation was measured at the base of the left ventricle in six basal segments outside the infarcted area. The results shown in Table 10 include the mean basal circumferential and radial deformation of the left ventricle. It is noted that in terms of circumferential deformation, this is lower in patients with left ventricular aneurysm than in patients with akinesia, but this difference is not statistically significant. Radial deformation of the left ventricle measured at the basal level was significantly higher in patients with left ventricular aneurysm expressing a greater radial function of the left ventricle at this level.

Another new parameter that expresses global systolic function of the left ventricle is left ventricular torsion, this type of deformation contributing to increased left ventricular pressure during systole with minimum energy consumption. LV basal and apical rotation have not been studied yet in patients with left ventricular aneurysm. Our results are presented in Table 12. It is noted that while apical rotation and LV torsion were lower in patients with left ventricular aneurysm than in patients with akinesia in the same territory, the results did not reach statistical significance.

The values of apical rotation and left ventricular torsion obtained in our study in these patients with apical aneurysm or akinesia in the left ventricular apex are, as expected, greatly reduced relative to the rotation and torsion in normal subjects (compared to the values that we obtained in various studies carried out in the Laboratory of Echocardiography, using a similar methodology). Apical rotation values measured in a group of 30 normal subjects with a mean age of 56 ± 12 years was 17 ± 6 ° in one of these studies and the torsion of the left ventricle of 2.8 ± 1.0 ° / cm. [12] Basal rotation values were similar in the study group with values obtained in normal subjects (-7.2 ± 3.4 in the group of patients with left ventricular aneurysm and -6.6 ± 3.4° in the study cited above).

Table 12. Parameters of left ventricular rotation and torsion

	Group 1 (aneurysm)	Group 2 (akinesia)	p
Apical rotation (°)	10.1 ± 3.7	11.5 ± 7.2	0.5
Basal rotation (°)	-7.2 ± 3.4	-6.7 ± 2.9	0.7
LV torsion (°/cm^2)	0.16 ± 0.06	0.22 ± 0.09	0.1

LV, left ventricle

In the entire study group, including patients with anterior left ventricular aneurysm and those with akinesia in the same territory, LV torsion was significantly correlated with left ventricular volume index, left ventricular dilation in patients with anterior myocardial infarction being associated to decreased left ventricular torsion. LV torsion was also significantly correlated with left ventricular ejection fraction and wall motion score index (Table 13).

Table 13. Correlations of left ventricular torsion parameters with parameters of left ventricular geometry and function in patients with anterior myocardial infarction

	LVEDVi	LVESVi	LVEF	WMSI
LV torsion	r=-0.49 p=0.03	r=-0.52 p=0.02	r=0.63 p=0.004	r=-0.61 p=0.006

LVEF, left ventricular ejection fraction; LVEDDi, indexed left ventricular enddiastolic diameter; LVESDi, indexed left ventricular endsystolic diameter; WMSI, wall motion score index;

Left ventricular diastolic function parameters

Comparative study of left ventricular diastolic function parameters between the two groups studied revealed no statistically significant differences in terms of analyzed variables. Transmitral diastolic flow analysis showed that patients with left ventricular aneurysm had a significantly lower E/A ratio compared to patients with akinesia in infarcted territory, by a significantly increased A wave velocity. E deceleration time (TDE) was similar in the two groups. Regarding parameters derived from tissue Doppler analysis of diastolic function we noted a significant decrease in early diastolic velocity values (E ') measured both at septal and lateral mitral annulus and a significantly increase in the E / E' ratio, as a noninvasive marker of filling pressures in the entire group compared to normal values. Early diastolic velocity (E ') and late diastolic velocity (A') at the septal and lateral mitral annulus were similar in the two groups, except that the values of lateral E ' were lower in patients with left ventricular aneurysm (p = 0.045). Left atrial dimensions were increased compared to normal values for the entire study group, reflecting the degree of diastolic dysfunction in patients with anterior myocardial, but they were not significantly different between groups.

Using the criteria recommended in the last diastolic function grading guide, developed by the European Association of Echocardiography in 2009[13], 60% of patients with left ventricular aneurysm were categorized as having grade 1 diastolic dysfunction and the rest had second degree diastolic dysfunction. In patients with akinesia in the infarcted territory, 45% had diastolic dysfunction grade 1, 35% grade 2 and 20% diastolic dysfunction of restrictive type. However, non-invasive assessment of filling pressures based on E / E'average ratio showed no significant differences between the two groups.

There were no significant differences between the two groups in terms of diastolic rotation parameters and left ventricular untwisting. Both diastolic apical rotation rates and ventricular untwisting and time interval to these events, were similar in patients with anterior aneurysm and those with akinesia in the same territory. Instead, the values of these parameters were significantly different from those obtained in normal subjects in studies using the same methodology, reflecting a late diastolic apical rotation and untwisting in patients with anterior myocardial infarction, regardless of the type of post-infarction scar.

Table 14. Diastolic rotation and untwisting parameters

	Group 1 (aneurysm)	**Group 2 (akinesia)**	**p**
Peak diastolic rotation rate (°/s)	-69 ± 31	-61 ±33	0.5
Time to peak apical diastolic rotation rate	0.59 ± 0.08	0.57 ±0.11	0.6
LV untwisting rate (°/s)	-100±41	-103±54	0.9
Time to peak LV untwisting rate	0.58±0.09	0.53±0.10	0.3

LV, left ventricle

Apical diastolic rotation rate was significantly correlated to indexed left ventricular volumes and left ventricular ejection fraction of the E / E' ratio, which reflects left ventricular filling pressure ($r = 0.57$, $p = 0.02$) – a decreased diastolic apical rotation rate is associated with increased filling pressures in patients with anterior myocardial infarction.

All these data reflect the presence of an "expected" diastolic dysfunction in patients with a history of anterior myocardial infarction, without significant differences between patients with left ventricular aneurysm and patients with akinesia in the infarcted territory.

2. Conclusions

In patients with left ventricular anterior aneurysm included in our study the degree of left ventricular dilatation and left ventricular ejection fraction were not significantly different compared to patients with akinesia in the same territory. Patients with large left ventricular aneurysms (over 40% of the left ventricle) had an advanced degree of global left ventricular systolic dysfunction, left ventricular aneurysm size being significantly correlated with ejection fraction and wall motion score.

Assessment of new myocardial deformation parameters and measurement of left ventricular volumes and ejection fraction by three-dimensional ultrasound is feasible in patients with left ventricular aneurysm, but due to the modified geometry of the ventricular apex it is sometimes impossible to aquire the appropriate images.

Left ventricular volumes measured by three-dimensional echocardiography in patients with ventricular aneurysm were higher on average than those measured by two-dimensional ultrasound and left ventricular ejection fraction was lower than that obtained by biplane Simpson method, suggesting a tendency to overestimate global function of the left ventricle using two-dimensional echocardiography.

Global left ventricular longitudinal deformation was lower in patients with anterior left ventricular aneurysm than those with akinesia in the same myocardial territory, but this difference was not statistically significant. In the group of patients with left ventricular aneurysm we found a strong correlation between global longitudinal deformation of the left ventricle and left ventricular ejection fraction.

Increased volumes in patients with left ventricular aneurysm were associated with decreased global left ventricular longitudinal strain and decreased myocardial velocities obtained by tissue Doppler at the septal and lateral mitral annulus.

Basal radial deformation of the left ventricle was significantly higher in patients with left ventricular aneurysm from patients with akinesia, expressing a greater radial function of the left ventricle at this level.

Apical rotation and LV torsion were lower in patients with anterior myocardial infarction, irrespective of the type of the infarction scar. Rotation and torsion parameter values were not significantly different between patients with aneurysm and those with akinesia in the same territory. There were no significant differences between the two groups studied either in terms of rotation parameters and diastolic left ventricular untwisting. In patients with left ventricular aneurysm, left ventricular torsion was directly correlated to left ventricular ejection fraction and inversely with the degree of left ventricular dilatation and wall motion score of the left ventricle.

Diastolic function data obtained in this study reflect the presence of an "expected" diastolic dysfunction in patients with a history of anterior myocardial infarction without significant differences between patients with left ventricular aneurysm and patients with akinesia in the infarcted territory.

Chapter IV

Study limitations

The main limitation of the study on the determinants of left ventricular aneurysm presence in patients with myocardial infarction derives from its retrospective nature, allowing the evaluation of a limited number of parameters available in the observation charts of included patients. However, the retrospective nature of the study allowed a large number of patients with left ventricular aneurysm (106 patients), which is difficult to achieve in prospective studies.

Low representation of patients with inferior myocardial infarction in the group of patients with ventricular aneurysm did not allow a separate analysis of them.

Although we included in our study only patients investigated by coronary angiography, data on the grading of coronary collateral circulation was available in a small proportion of patients, this type of evaluation was not included in the standard protocol in clinical practice.

The study did not include a follow-up period, which did not allow us to study the predictive role of clinical, echocardiographic and angiographic parameters on the evolution of these patients.

A prospective study limitation is the small number of patients included in the final analysis, provided that full and comprehensive echocardiographic examination was available in a small proportion of cases. The presence of anterior left ventricular aneurysm, especially when it is large, makes it difficult to obtain accurate echocardiographic images allowing the visualization of the entire left ventricular endocardium for an adequate measurement parameters of global and regional systolic function.

Some limitations are related to the method used to assess myocardial deformation (twisting and untwisting of the left ventricle and left ventricular global longitudinal strain and basal circumferential and radial deformation). Although speckle tracking echocardiography is a validated method versus magnetic resonance imaging and sonomicrometry, there are some recognized limitations of this method. One of the most important is related to the difficulty of section plans selection to obtain the short axis images of the left ventricular apex – which is difficult to standardize in two-dimensional echocardiography. This is very important as the way in which this is carried is very important for the measurement of apical rotation, a parameter that significantly influences subsequent calculation of left ventricular torsion. Moreover, in patients with left ventricular dilatation and modified geometry of the ventricular apex this limitation becomes very important.

All echocardiographic examinations were performed in an european accredited echocardiography laboratory, with a 5 years experience in evaluating these parameters, most examinations were performed in very good technical conditions, by experienced echocardiographists and analyzed offline by the same observer. Intraobservator variability for measuring the parameters of rotation and torsion in our laboratory falls within acceptable limits cited for this technique.

Another limitation of the method of assessment of left ventricular rotation and twist and circumferential and radial deformation parameters is related to the acquisition of the basal section of the left ventricle which can be problematic because of the through plane movement of left ventricular base during cardiac cycle, which makes the tracking of intramyocardial markers to be more difficult than for the apical section[14].

Final conclusions

Left ventricular aneurysm is a frequent pathology in a tertiary cardiology clinic, being diagnosed in one third of patients hospitalized with a diagnosis of myocardial infarction in the first year of evolution.

The presence of left ventricular aneurysm has a negative impact on functional status, left ventricular structure and function and is associated with worsening heart failure, increased ventricular size and decreased left ventricular ejection fraction.

Comparative analysis of angiographic characteristics between patients with left ventricular aneurysm and those without aneurysm shows that there are no significant differences in the number of angiographically significant coronary lesions and their distribution.

Non-smoking status, presence of anterior descending artery occlusion and lack of primary coronary angioplasty were factors independently correlated with the presence of left ventricular aneurysm in patients in the first year after an acute ST elevation myocardial infarction.

In patients with anterior myocardial infarction, anetrior descending artery occlusion and lack of reperfusion therapy were independent determinants of left ventricular aneurysm formation.

The degree of left ventricular dilatation and left ventricular ejection fraction in patients with anterior left ventricular aneurysm prospectively included in our study were not significantly different compared to patients with akinesia in the same territory.

Left ventricular aneurysm size was significantly correlated with left ventricular ejection fraction and wall motion score.

In patients with anterior left ventricular aneurysm the assessment of new deformation parameters and the measurement of left ventricular volumes and left ventricular ejection fraction by three-dimensional ultrasound is feasible, with difficulties related to the altered geometry of ventricular apex, which sometimes makes the acquisition of appropriate images impossible.

Left ventricular volumes measured by three-dimensional echocardiography in patients with ventricular aneurysm were on average higher and left ventricular ejection fraction was lower than those measured by two-dimensional ultrasound, suggesting a tendency to overestimate global left ventricular systolic function using conventional echocardiography.

Global left ventricular longitudinal deformation is significantly correlated with left ventricular ejection fraction and wall motion score index in patients with left ventricular aneurysm.

Increased volumes in patients with left ventricular aneurysm was associated with decreased global left ventricular longitudinal strain and decreased systolic myocardial velocities obtained by tissue Doppler at the level of the mitral annulus.

Basal radial deformation of the left ventricle was significantly higher in patients with anterior left ventricular aneurysm than in patients with akinesia in the same territory, expressing a better radial function of the left ventricular base in these patients.

Apical rotation and LV torsion were lower in patients with old anterior myocardial infarction, irrespective of the type of infarction scar. The values of these parameters were not significantly different between patients with aneurysm and those with akinesia in the same territory.

In patients with left ventricular aneurysm, left ventricular torsion correlated directly with left ventricular ejection fraction and inversely with the degree of left ventricular dilatation and wall motion score index of the left ventricle.

In our study there were no significant differences regarding diastolic function parameters among patients with left ventricular aneurysm and patients with akinesia in the same myocardial territory.

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