Original Article

Impact of Ventricular Geometric Pattern on Cardiac Remodeling after Myocardial Infarction

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Abstract

Background: The relevance of left ventricular (LV) geometric pattern after myocardial infarction is not known.

Objectives: To analyze the presence of different LV geometric patterns and their impact as a predictor of remodeling in patients with myocardial infarction.

Methods: Patients with anterior acute myocardial infarction (n = 84) were divided according to the geometric pattern: normal (normal left ventricular mass index [LVMI] and normal relative wall thickness [RWT]), concentric remodeling (normal LVMI and increased RWT), concentric hypertrophy (increased LVMI and RWT) and eccentric hypertrophy (increased LVMI and normal RWT). After six months, echocardiographic assessment was repeated.

Results: Four patients died. Of the survivors, 41 showed remodeling (R +), whereas 39 did not (R-). Considering the geometric pattern, the cases were distributed as follows: 24 patients with normal pattern, 13 with concentric remodeling, 29 with concentric hypertrophy and 14 with eccentric hypertrophy. Patients who showed remodeling had larger infarction sizes analyzed by peak CPK (R + = 4,610 (1,688-7,970), R- = 1,442 (775-4247), p <0.001) and CK-MB (R + = 441 (246 - 666), R- = 183 (101-465), p <0.001), trend towards higher prevalence of concentric remodeling (R+ = 10, R- = 3, p = 0.08) and lower prevalence of eccentric hypertrophy (R + = 2 R- = 12, p = 0.006). In the multivariate regression analysis, infarction size was a predictor (OR = 1.01, p = 0.020) and eccentric hypertrophy was a protective factor (OR = 0.189, p = 0.046) of ventricular remodeling after coronary occlusion.

Conclusion: The LV geometric pattern can have an impact on the remodeling process in patients with myocardial infarction. (Arq Bras Cardiol. 2013;100(6):518-523)

Keywords: Ventricular Remodeling; Myocardial Infarction; Ventricular Function, Left; Hypertension.

Introduction

After cardiac injury, molecular, cellular and interstitial alterations may occur in the heart, which will manifest clinically as alterations in heart architecture, mass, geometric pattern, function and size. This phenomenon is called cardiac remodeling[1,2] and plays a key role in the physiopathology of ventricular dysfunction that occurs in different models of cardiac injury[3,4].

For this reason, we seek to identify variables associated with the remodeling process that could stratify the risk of cardiovascular events. Among these indices, the left ventricular (LV) geometric pattern is particularly significant.

It has been observed in hypertensive patients that pressure overload can result in different geometric patterns. Using the LV mass index (LVMI) and relative wall thickness (RWT) as echocardiographic variables, the patients were divided into four different geometric patterns: normal (normal LVMI and normal RWT), concentric remodeling (normal LVMI and increased RWT), concentric hypertrophy (increased LVMI and increased RWT) and eccentric hypertrophy (increased LVMI and normal RWT). In this model, the concentric hypertrophy pattern was predictive of cardiovascular events[5].

One must consider, however, that the importance of cardiac remodeling pattern after acute myocardial infarction remains to be clarified. Thus, the objective of the present study was to analyze the presence of different left ventricular (LV) geometric patterns and their impact as predictors of remodeling in patients with myocardial infarction of the anterior wall.

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Methods

Design

This was a prospective observational study, carried out in the coronary care unit of our institution. Consecutive patients of both sexes that had the first episode of anterior wall AMI from December 2008 to July 2010 were included. The diagnosis of anterior wall AMI was established by history of chest pain lasting longer than 20 minutes and the presence of ST-segment elevation in at least two contiguous precordial leads (V1-V4) or the presence of new complete left bundle-branch block at electrocardiogram. Exclusion criteria were the presence of congenital heart disease, significant primary valvular disease, atrial fibrillation, inadequate circumstances to undergo the first echocardiogram during hospitalization, inadequate echocardiographic window, cancer, autoimmune disease, chronic renal failure (creatinine clearance ≤ 30 mL/min), liver failure and chronic therapy with immunosuppressant agents.

The study protocol was approved by the Ethics Committee of our institution, and patients were enrolled after signing the free and informed consent form. During hospitalization, patients were evaluated daily and submitted to the first echocardiogram; follow-up duration after hospital discharge was six months, and at that time, patients underwent clinical reassessment and a new echocardiogram.

Clinical variables

Data related to patient clinical profiles were obtained from medical history and physical examination on admission. Blood samples were obtained according to the coronary care unit routine. Electrolytes, renal function and blood count were measured on admission and blood glucose and lipids were measured in samples obtained after a 12-hour fast. The levels of total creatine phosphokinase (CPK) and MB isoenzyme (CK-MB) were evaluated at baseline and every six hours until their levels started to decrease. Two troponin I measurements were performed (at baseline and 90 minutes after patient arrival).

Clinical variables, risk factors, prescription drugs and other definitions used in this study were similar to the variables used in other clinical studies[6-8].

Echocardiographic assessment

LV morphological and functional assessment was performed by echocardiography. The examinations were performed by three echocardiographists blinded to patients' clinical characteristics and treatment. Echocardiograms were performed in-hospital and six months after the AMI by the same examiner. In our service, the interobserver variability is < 5% for one-dimensional and < 10% for two-dimensional measurements and Doppler-derived time variables; the intraobserver variability is < 5% for all variables.

The examinations were performed in Philips HDI-5000 equipment according to the standard technique[9]. LV mass was calculated by the formula $M = 0.8 \times [1.04 \times (\text{IVS thickness} + \text{thickness of PW} + \text{LV diastolic diameter})^3 - (\text{LV diastolic diameter})^3] + 0.6$, where IVS is the interventricular septum thickness and PW is the LV posterior wall. The mass was corrected for body surface area for LVMI.

The relative wall thickness (RWT) was calculated by the formula RWT = 2x PW thickness / LVDD, where LVDD is the left ventricular diastolic diameter.

Regarding the geometric pattern, the LVMI was considered increased when > 115 g/m^2 and RWT was considered increased when > 0.42[10]. Patients were divided according to the geometric pattern: normal (normal LVMI and normal RWT), concentric remodeling (normal LVMI and increased RWT), concentric hypertrophy (increased LVMI and RWT) and eccentric hypertrophy (increased LVMI and normal RWT).

Ventricular remodeling was defined as an increase of at least 15% in LV systolic and/or diastolic volume detected between the first and second echocardiography[11].

Statistical analysis

Continuous variables are shown as mean and standard deviation or median and 25% and 75% percentiles in case of non-normal distribution. The proportional variables were analyzed by Chi-square test or Fisher's test for comparison between groups. Continuous variables were tested for normality; continuous variables with normal distribution were compared by Student's *t* test (comparisons between two groups) and ANOVA, while non-normal continuous variables were compared by Mann-Whitney test (comparisons between two groups) and Kruskal-Wallis test.

The associations between the geometric pattern and remodeling after myocardial infarction were analyzed by multivariate logistic regression analysis. The statistical package SigmaStat for Windows release 3.5 (Systat Software Inc. - San Jose, CA - USA) was used for the analyses. The level of significance was set at 5% for all tests.

Results

During the study period, 90 consecutive patients were evaluated. Of these, three patients did not agree to participate, three patients had atrial fibrillation, and four patients died within six months. Therefore, our sample consisted of 80 patients.

Regarding the remodeling process, 41 patients had remodeling (R +), whereas 39 patients did not (R-). Patients' clinical characteristics are shown in Table 1. It can be observed that the infarction size was higher in patients who progressed to remodeling.

Regarding the geometric pattern, 24 patients had a normal pattern (N), 13 had concentric remodeling (CR), 29 had concentric hypertrophy (CH) and 14 had eccentric hypertrophy (EH). Patient geometric pattern in relation to the remodeling process is shown in Table 2. It can be observed that patients with remodeling showed a tendency toward a higher prevalence of concentric remodeling (R+ = 10 +, R- = 3, $p = 0.08$) and lower prevalence of eccentric hypertrophy (R + = 2, R- = 12, $p = 0.006$).

Table 1 – Clinical characteristics

Variables	Ventricular remodeling		p
	Yes (n = 41)	No (n = 39)	
Age (years)	55 ± 11	60 ± 13	0.070
Male sex, (nº)	31	28	0. 894
SAH, (nº)	23	24	0.848
DM, (nº)	11	11	0.910
Dyslipidemia, (nº)	25	23	0.964
Smoking, (nº)	20	14	0.348
BMI (kg/m2)	27 ± 4	26 ± 3	0.879
Angioplasty, (nº)	30	23	0.269
Thrombolysis, (nº)	8	6	0.848
CPK (U/L)	4.610 (1.688-7.970)	1.442 (775-4.247)	< 0.001
CPK-MB (U/L)	441 (246-666)	183 (101-465)	< 0.001

SAH: systemic arterial hypertension, DM: diabetes mellitus, BMI: body mass index; CPK: creatine phosphokinase, CPK-MB: creatine phosphokinase – MB fraction. Data are expressed as mean and standard deviation or median and 25% and 75% percentiles.

Table 2 - Geometric pattern

Variables	Ventricular remodeling		p
	Yes (n = 41)	No (n = 39)	
Normal, (nº)	13	11	0.922
CR, (nº)	10	3	0.085
CH, (nº)	16	13	0.767
EH, (nº)	2	12	0.006

CR: concentric remodeling, CH: concentric hypertrophy, EH: eccentric hypertrophy.

Considering the association between LV geometric pattern and function, patients with eccentric hypertrophy showed lower ejection fraction than patients with concentric hypertrophy (N = 0.48 ± 0.08, CR = 0.48 ± 0.10 , CH = 0.49 ± 0.10, EH = 0.40 ± 0.09, p = 0.026). There were no other differences.

Regarding the association between the geometric pattern and the treatment used, no differences were observed between the groups, particularly with medications of which properties attenuate remodeling (Table 3).

In the multivariate regression analysis, infarction size was a predictor and eccentric hypertrophy was a protective factor for ventricular remodeling after coronary occlusion (Table 4).

Discussion

The identification of cardiac remodeling predictors can help the therapeutic management after myocardial infarction and, therefore, has been the subject of experimental[12-15] and clinical[6,7] studies. Considering the lack of information on the relevance of the remodeling pattern in the acute myocardial infarction model, the aim of the study was to analyze the presence of different remodeling patterns and their association with ventricular function in this model.

The first aspect to be considered is the presence of different geometric patterns. In cases of hypertension, the four different geometric patterns are explained by the different physiopathological mechanisms for hypertension, with different hemodynamic patterns. Thus, the geometric pattern would depend on the degree of vasoconstriction, intensity of neurohumoral factor activation and presence of volume overload[16]. Verna et al., in an analysis of the VALIANT Echocardiographic Study[10] in the myocardial infarction model, observed the four geometric patterns in patients with left ventricular dysfunction after myocardial infarction: concentric hypertrophy (12.6%), eccentric hypertrophy (18.6%) concentric remodeling (18.2%) and normal pattern (50.6%). In this study, the different geometric patterns are attributed to the different comorbidities shown by patients, such as arterial hypertension.

In our study, patients with anterior wall myocardial infarction also had the four geometric patterns, which could

Table 3 - Geometric pattern and treatment

	Normal (n = 24)	CR (n = 13)	CH (n = 29)	EH (n = 14)
RT, (n)	21	10	21	11
Beta-blocker, (n)	22	12	26	13
ACEI, (n)	22	11	26	13
Spironolactone, (n)	2	3	6	5
ASA + Clopidogrel, (n)	24	13	29	14

RT: reperfusion therapy, ACEI: angiotensin-converting enzyme inhibitors; CR: concentric remodeling, CH: concentric hypertrophy, EH: eccentric hypertrophy. P < 0.05 between groups for all variables; ASA: acetylsalicylic acid.

Table 4 - Multivariate regression for ventricular remodeling predictors

	OR	5%	95%	p
Age	0.976	0.935	1.019	0.270
Male sex	0.885	0.274	2.864	0.839
CPK	1.010	1.000	1.100	0.020
CR	3.085	0.707	13.462	0.134
EH	0.189	0.0369	0.972	0.046

CPK: creatine phosphokinase; CR: concentric remodeling, EH: eccentric hypertrophy.

be explained by different clinical characteristics. However, in experimental models, mice with myocardial infarction and exposed to cigarette smoke also showed different geometric patterns[17,18]. Considering that the animals had the same characteristics (strain, age, gender, origin, acclimatization conditions) and no comorbidities, these findings suggest that animals with the same characteristics respond differently when exposed to the same offending agent.

Another important aspect is that different authors have shown that the remodeling pattern may have prognostic implications. Thus, in patients with hypertension, the concentric hypertrophy pattern has been associated with increased risk of cardiovascular events when compared to other geometric patterns[19].

Other studies have suggested that concentric remodeling is associated with increased risk of cardiovascular events[20-24]. On the other hand, the geometric pattern was not associated with worse prognosis in other studies[25-27], indicating that the relevance of the remodeling pattern in hypertensive patients remains a controversial issue. In patients with acute myocardial infarction, the LVMI, RWT and concentric hypertrophy geometric pattern were independent predictors of death[10]. We are not aware of studies that evaluated the relevance of geometric patterns as predictors of remodeling in the acute myocardial infarction model.

In this sense, one should consider that the cardiac remodeling process after myocardial infarction is well characterized. In infarcted hearts, the ventricle loses its normal elliptical form after the expansion, taking on a spherical shape. With this new format, there is increased wall tension, with significantly greater increase during diastole than in systole. It is believed that the increased stress stimulates sarcomere replication, preferably in series. Therefore, larger ventricular cavities in the acute phase of myocardial infarction would be stimulate subsequent ventricular dilatation, which clinically characterizes the cardiac remodeling process after myocardial infarction[1,2,4,28]. Our study, however, did not confirm this theory. Differently from what was expected, the presence of eccentric dilation in the early phase was a protective factor for the occurrence of remodeling after six months of coronary occlusion. An important aspect to be considered is that the mechanisms responsible for this phenomenon remain to be investigated.

Finally, we must consider that different therapeutic strategies can modulate the remodeling process after infarction. Among them, reperfusion therapy, angiotensin-converting enzyme inhibitors, beta-blockers and aldosterone antagonists are significant in clinical practice.

Thus, the treatment used during the recovery phase may be a confounding factor in studies that assess the remodeling process after infarction. However, we must emphasize that in our study, there were no differences in treatment among patients who progressed or not with remodeling or between patients with different geometric patterns. Thus, this finding has two implications. First, the process of remodeling remains a frequent event after anterior wall myocardial infarction, although adequately treated. Additionally, it can be inferred that the treatment did not influence our results on the relevance of the geometric pattern as a determinant of remodeling in this model.

In conclusion, the ventricular geometry pattern can have an impact on the remodeling process in patients with myocardial infarction of the anterior wall.

Author contributions

Conception and design of the research: Farah E, Paiva SAR, Zornoff LAM; Acquisition of data: Farah E, Fusco DR, Okumoto PRR, Azevedo PS, Matsubara BB, Okoshi K, Zanati SG; Analysis and interpretation of the data: Farah E, Fusco DR, Minicucci MF, Azevedo PS, Matsubara BB, Okoshi K, Zanati SG, Paiva SAR, Zornoff LAM; Statistical analysis: Minicucci MF, Paiva SAR; Writing of the manuscript: Minicucci MF, Zornoff LAM; Critical revision of the manuscript for intellectual content: Azevedo PS, Paiva SAR, Zornoff LAM.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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