Relationship between functional capacity and diastolic function in early myocardial infarction

Relação entre capacidade funcional e função diastólica no infarto recente

Relación entre capacidad funcional y función diastólica en el infarto reciente

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ABSTRACT | The myocardial infarction (MI) alters left ventricle diastolic function (LVDF) in different grades, which may reflect on functional capacity (FC). This study aimed to assess, in patients with recent MI, the relation between LVDF and FC evaluated by the distance covered during the six minute walking test (6MWT). Fifty-six uncomplicated MI inpatients were selected after discharge from the coronary care unit and submitted to tests. Statistic analyses were carried out considering all patients for correlations and groups according to the classification of LVDF to comparison. It was found correlation between lateral wave a' (later diastole) and 6MWD (r=-0.320; p=0.023) and no difference between FC and LVDF between groups. Blood pressure and heart rate had physiologic responses. The correlation indicates that the impairment of early diastole expands the role of atrial contraction in CF, reinforcing the need for evaluation of these patients still in the hospital. The physiological responses related to the six minute walking test reinforce the feasibility of its use after recent MI.

Keywords | exercise test; echocardiography; myocardial infarction; diastole.

RESUMO | O infarto do miocárdio (IM) altera a função diastólica (FD) do ventrículo esquerdo (VE) em diferentes graus, o que pode refletir na capacidade funcional (CF). O objetivo deste estudo foi avaliar, após IM recente, a relação entre a FD do VE por meio de ecocardiografia Doppler e a CF estimada por meio da distância percorrida no teste de caminhada de seis minutos (DP6). Cinquenta e seis pacientes com IM não complicado foram selecionados após a alta da unidade coronariana e submetidos aos testes. Foi realizada análise de correlação considerando todos os pacientes e de comparação entre grupos definidos de acordo com a classificação da FD do VE. Foi observada correlação entre a onda a' lateral (referente à diástole tardia) e a DP6 (r=-0,320; p=0,023) e não houve diferença entre a CF dos grupos classificados conforme a FD do VE. As respostas de pressão arterial e frequência cardíaca ao teste foram fisiológicas. A correlação encontrada indica que o comprometimento da diástole precoce amplia o papel da contração atrial na CF, reforçando a necessidade de avaliação desses pacientes ainda no hospital. A resposta fisiológica ao TC6 reforça a viabilidade de sua utilização após IM recente.

Descritores | teste de esforço; ecocardiografia; infarto do miocárdio; diástole.

RESUMEN | La relación entre la capacidad funcional (CF) y la función diastólica (FD) del ventrículo izquierdo (VI) no es clara en condiciones cardíacas agudas, como el infarto agudo de miocardio (IAM). El objetivo de este estudio fue evaluar la relación entre la CF, evaluada por medio de la distancia recorrida en el test de marcha de seis minutos (DTM6) y la FD del VI evaluada por medio de ecocardiografía Doppler después del IAM reciente. Cincuenta y seis pacientes con IAM no complicado fueron seleccionados después del alta de la unidad coronaria y fueron luego

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Presentation: Sept. 2012 – Accepted for publication: Mar. 2013 – Financing source: FAPEMIG – Proccess PPM-072-09 and CNPq 307597/2011-3 – Conflict of interest: nothing to declare – Approval at the Ethics Committee n. 0515.0.203.000-10.

sometidos a los tests. Fue realizado el análisis estadístico considerando todos los pacientes y por grupos, de acuerdo a la clasificación de la FD del VI. Fue observada una correlación entre la onda a' lateral (referente a la diástole tardía) y la DTM6 (r=-0,320; p=0,023). Sin embargo, no hubo asociación entre la CF y la FD del VI en el análisis por grupos. La correlación entre la DTM6 y la onda a´ lateral indica asociación entre la diástole tardía y la CF en estos pacientes, sugiriendo una mayor contribución de la contracción auricular para la promoción del llenado del VI en esta población. Estos datos proporcionan una asignación adicional para la utilización del TM6 en la evaluación de la CF después de un IAM reciente.

Palabras clave | test de marcha de seis minutos; ecocardiograma; infarto agudo de miocardio reciente.

INTRODUCTION

Myocardial infarction (MI) is defined by the total interruption of the coronary flow with consequent ischemia and myocardial necrosis[1]. In MI, the diastolic function (DF) of the left ventricle (LV) is rapidly altered[2,3], since part of the diastole depends on energy[4-6]. DF of the LV is associated with functional capacity (FC) in different populations[7-10], but it is little investigated in acute conditions[11].

The six-minute walking test (6MWT) is a submaximal, reliable, practical and low cost test[12-15] to assess the FC of healthy subjects, as well as cardiac[16] and lung disease patients[17]. Its use in MI before hospital discharge is recent[18] and little discussed[19]. The evaluation of FC in the hospital assists risk stratification and medical therapeutics and, especially, the proper prescription of exercise[15-20].

It is likely that patients with higher degree of diastolic dysfunction (reduced DF of the LV) present reduced FC, proportional to the severity. Thus, the main objective of this study was to assess the relation between FC and DF of the LV in patients after recent MI, and also to identify the behavior of physiological variables during the application of the 6MWT.

MATERIALS AND METHODS

Cross-sectional study that assessed volunteers diagnosed with MI with or without the elevation of the ST segment (MI CSST and MI SSST), uncomplicated, after discharge from the coronary unit and medical. MI was defined by: ischemic symptoms, elevated troponin and evaluation of electrocardiogram (ECG). MI CSST was characterized by the presence of SST in at least two consecutive derivations in ECG and MI SSST due to the absence of changes in the ECG or the presence of changes indicating ischemia, different from SST[21]. Patients higher than I in the Killip classification[22] were excluded (clinical signs of ventricular dysfunction), as well as those with persistent arrhythmias, myocardial ischemia at the ECG, instability of pressure levels, moderate to severe mitral valve insufficiency[23,24] or difficulties for walking. The patients were divided into groups according to the DF classification of the LV. The study was approved by the Research Ethics Committee of the institution (Report n. 0515.0.203.000-10), and all the volunteers signed the informed consent form.

- 6MWT. FC was assessed by means of distance walked in the 6MWT (6DW), according to the guidelines by the American Thoracic Society (ATS)[12]. Heart rate (HR), blood pressure, saturation of peripheral oxygen (SpO_2), and perceived exertion were assessed before and after the test (at the end and after five minutes), by means of the cardio frequency meter (Polar®, FS2c, Finland), auscultatory method, wrist oximeter (Mindray®, PM50, China) and the modified Borg Scale[23], respectively. HR and SpO_2 were monitored also during the performance of the test. 6MWT was performed by the same examiner twice (due to the learning effect[12,13]) on the same day, with rest interval[12,13]. The longest distance walked was considered. Signs and symptoms of exertional intolerance[12] and elevated HR, higher than 85% in relation to the estimated HR for the age, were used as criteria to interrupt the test[15].
- ECHO. The diastolic function (DF) of the left ventricle (LV) can be assessed by different parameters, such as the E/A ratio and the E/e' ratio[25,26]. The E and A waves refer to the blood flow in the mitral valve during early and late diastole, respectively. The e' wave and the a' wave represent, respectively, the myocardial displacement in the mitral ring during early and late diastole. The E/e' ratio has been the most used parameter to assess DF and LV, since it is less influenced by other physiological variables[25,26]. Examinations were performed by experienced echocardiographists who did not have access to clinical data. The echocardiography system Philips IE 33 (USA, 2010) was used, with a multifrequency transducer of 2 to 4 mHz to obtain bidimensional images of the M mode

and with pulsatile Doppler. Mitral inflow velocities were registered with the pulsatile Doppler in the apical four chamber cut, with a 5 mm sample volume of at the tip of the mitral leaflets. The velocities of early (E) and late (A) diastole were measured, and the E/A ratio was also calculated. A 2 mm sample volume was placed at the junction of the LV wall and the mitral ring, in the septal and lateral regions, for the tissue Doppler register, deriving the velocities during systole (s'), early diastole (e') and late diastole (a').

The left ventricular ejection fraction (LVEF) was calculated by the Simpson method[24]. The compromised systolic function was considered as LVEF <50%[27]. The DF of the LV was classified, according to the E/A ratio, as normal, abnormal diastolic relaxation (ADR), pseudonormal relaxation (PR) or restrictive (RE)[26]. The E/e' ratio was calculated to estimate LV filling pressures[26]. The E/e' ratio <8 is associated with normal LV filling pressures, and the E/e' ratio >13 is associated with high LV filling pressures in patients with normal LVEF, when the mean of septal and lateral e' was used for calculation[26].

Statistical analysis

An assessment of normality of data distribution by the was conducted by the Kolmogorov-Smirnov test, ANOVA one-way and the least significant difference test or the χ^2 test, to compare between groups. Pearson or Spearman correlation was used to assess the relation between the 6MWT and the echocardiographic parameters. Data are presented as absolute frequency, percentage and mean ± deviation, considering α=5% as being significant.

RESULTS

Seventy-two patients were selected, and some of them were excluded: 3 due to compromised deambulation, 8 for not being submitted to ECHO during hospital stay, 4 for using another device, and 1 due to severe mitral dysfunction. Therefore, 56 subjects were included and their characteristics are presented in Table 1. Most patients (71.42%) underwent revascularization by means

Table 1. Characteristics of subjects

	Total of subjects	Group 1 (normal DF) n=9	Group 2 (ADR) n=36	Group 3 (PR) n=11
Characteristics				
Male	42 (75)	6 (66.66)	27 (75)	9 (81.81)
Age (years)	56±10	49.88±7.93	57.50±8.62	57.00±14.39
BMI (kg/m^2)	26.91±4.52	26.12±4.15	27.63±5.13	27.00±3.54
Risk factors				
FH ACD	7 (12.5)	1 (11.11)	5 (13.88)	1 (9.09)
SAH	34 (60.71)	4 (44.44)	26 (72.22)	4 (36.36)
DM	10 (17.85)	2 (22.22)	7 (19.44)	1 (9.09)
Dyslipidemia	36 (64.28)	6 (66.66)	22 (61.11)	8 (72.72)
Smoking	24 (42.85)	7 (77.77)	11 (30.55)	6 (54.54)
Sedentary lifestyle	50 (89.28)	7 (77.77)	32 (88.88)	11 (100)
Regions affected by the MI EST				
Anterior	13 (23.21)	3 (33.33)	8 (22.22)	2 (18.18)
Anteroseptal	10 (17.85)	0	8 (22.22)	2 (18.18)
Ânterior-posterior	1 (1.78)	0	1 (2.77)	0
Anterolateral	4 (7.14)	1 (11.11)	2 (5.55)	1 (9.09)
Ânterior-lateral-inferior	1 (1.78)	0	1 (2.77)	0
Lateral	2 (3.57)	2 (22.22)	0	0
Lateroseptal	1 (1.78)	0	1 (2.77)	0
Inferior	4 (7.14)	1 (11.11)	2 (5.55)	1 (9.09)
Inferior-lateral	5 (8.92)	0	3 (8.33)	2 (18.18)
Inferior-lateral-posterior	2 (3.57)	0	1 (2.77)	1 (9.09)
Inferior-posterior	1 (1.78)	0	0	1 (9.09)
Inferior-posterior+RV	1 (1.78)	0	1 (2.77)	0
MI WEST	11 (19.64)	2 (22.22)	8 (22.22)	1 (9.09)

Values expressed as absolute frequency and percentage (%) or mean±standard deviation (age and BMI). No significant differences were observed between the grouops by the ANOVA or the χ^2 test. DF: diastolic function; ADR: abnormal diastolic relaxation; PR: pseudonormal relaxation; BMI: body mass index; FH ACD: family history of atherosclerosis coronary disease; SAH: systemic arterial hypertension; DM: *diabetes mellitus*; MI EST: myocardial infarction with elevated ST segment; MI WEST: myocardial infarction without elevated ST segment; RV: right ventricle

Table 2. Echocardiographic characteristics

Parameters	Total of subjects	Group 1 (DF normal) n=9	Group 2 (ADR) n=36	Group 3 (PR) n=11	F	p-value
Ejection fraction (%)	53.36±10.65	59.25±7.74	54.63±10.12	47.91±11.19	2.799	0.070
Velocity mitral E wave (cm/s)	71.10±18.48	84.12±10.11	60.46±13.72*	90.63±15.91	26.965	<0.001
Velocity mitral A wave (cm/s)	70.59±19.02	55.12±7.58	80.23±15.89*	56.45±20.51#	12.553	<0.001
E/A ratio	1.12±0.62	1.54±0.30	0.77±0.18*	1.84±0.92#	27.457	<0.001
E/e' ratio	9.67±4.11	7.75±1.48	9.13±3.41	12.90±6.30*#	5.370	0.008
Velocities of the mitral ring						
Velocity e' septal region (cm/s)	6.28±2.43	9.75±3.15	5.30±1.57*	6.09±1.64*	20.481	<0.001
Velocity e' lateral region (cm/s)	8.25±3.51	11.87±3.97	7.23±2.81*	8.45±3.75*	7.149	0.002
Velocity a' septal region (cm/s)	8.35±2.22	8.37±1.68	8.83±2.10	6.90±2.70#	3.491	0.038
Velocity a' lateral region (cm/s)	9.19±3.04	8.37±3.37	10.00±2.25	7.81±4.30	2.328	0.108
Velocity s' septal region (cm/s)	6.18±1.95	7.12±2.53	5.96±1.75	6.18±2.22	1.641	0.204
Velocity s' lateral region (cm/s)	7.01±2.67	7.87±2.35	6.60±2.34	7.00±3.13	0.496	0.612

Values expressed as mean±standard deviation. DF: diastolic function; ADR: abnormal diastolic relaxation; PR: pseudonormal relaxation
*p<0.05: comparison of Groups 2 and 3 in relation to Group 1 with normal DF
#p<0.05: comparison between Groups 2 and 3, ANOVA and least significant difference

Table 3. Data from the 6MWT

Variables	Total of subjects n=56	Group 1 (DF normal) n=9	Group 2 (ADR) n=36	Group 3 (PR) n=11	F	p-value
Time after MI (days)	5.18±2.26	5.11±2.47	5.15±2.31	5.36±2.33	0.045	0.956
Distance walked (meters)	447.23±80.27	452.33±82.27	444.67±71.13	457.72±104.93	0.164	0.849
HR at rest (bpm)	74.84±12.30	71.78±15.36	75.24±11.56	75.18±13.52	0.327	0.723
Peak HR (bpm)	105.23±16.94	102.67±19.41	101.74±13.51	114.64±18.31	2.202	0.121
Delta HR (bpm)	29.87±12.84	30.89±13.05	26.50±11.21*	39.45±13.50*	3.671	0.032
Inicial SAP (mmHg)	97.78±15.74	93.33±10.00	102.35±16.70*	87.27±10.09*	4.954	0.011
Final SAP (mmHg)	120.00±21.10	120.00±20.61	121.47±22.58	115.45±17.52	0.329	0.721
Inicial DAP (mmHg)	63.15±10.42	60.00±5.00	66.18±11.28*	56.36±6.74*	4.675	0.014
Final DAP (mmHg)	69.07±9.76	64.44±7.26	70.59±10.42	68.18±8.73	1.493	0.234
Final SpO_2 (%)	95.93±2.65	95.00±3.04	95.24±2.20	95.64±3.66	0.879	0.421
Final PE (MBS)	2,27±1.27	2.22±1.78	2.32±1.12	2.18±1.47	0.045	0.956
Double product (bpm x mmHg)	12,582.78±3,229.60	12,386.67±3,847.62	12,402.94±3,087.88	12,299.09± 3,355.99	0.331	0.720

Values expressed as mean±standard deviation. DF: diastolic function; ADR: abnormal diastolic relaxation; PR: pseudonormal relaxation; MI: myocardial infarction; HR: heart rate; bpm: beats per minute; SAP: systolic arterial pressure; DAP: diastolic arterial pressure; SpO_2: peripheral oxygen saturation; PE: perceived exertion; MBS: modified Borg Scale; *p<0.05. ANOVA and least significant difference.

of thrombolysis (30.35%), angioplasty (64.28%) or both, before the performance of the 6MWT, and 53 (94.64%) were on beta blockers.

The echocardiographic analysis (Table 2) showed that 18 patients (32.14%) had systolic dysfunction, and 47 (83.93%), diastolic dysfunction. Only 8 (14.28%) had high LV filling pressures; all of these presented with diastolic dysfunction, being 3 with PR and 5 with ADR. According to the classification of the DF of the LV, the following proportion was observed: normal FD: 16.07% (9 patients), ADR: 64.29% (36 patients), PR: 19.64% (11 patients) and RE: 0% (no patient). Therefore, three groups were considered for comparison (1 to 3). There was no statistical difference between the base characteristics of the groups (Table 1). However, as expected, differences were observed in echocardiographic variables (Table 2).

There was correlation (Figure 1) betwen the lateral a' wave and the 6MWT. There was no difference in the 6MWT in the analysis per group (Table 3). In the 6MWT, only one patient surpassed the defined HR limit. The others presented physiological behavior of the assessed variables (Table 3).

DISCUSSION

This study indicates that: 1) the correlation between the 6MWT and the lateral a' wave (late diastole), even if with low magnitude, suggests a greater contribution of the atrial contraction for the LV filling; 2) there is no difference in the 6MWT in groups with different DF of the LV; and 3) no adverse physiological response to the 6MWT was found in the assessed patients.

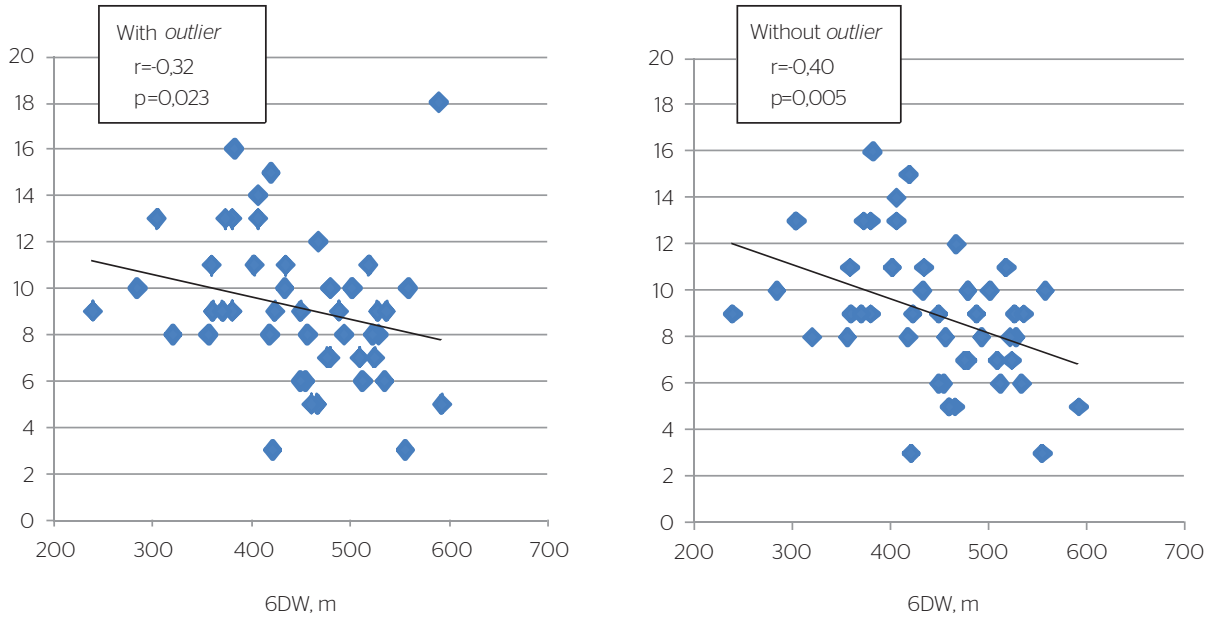

Figure 1. Graphic representation of the Spearman correlation between the distance walked in 6 minutes (6DW) and a' lateral velocity with (left) and without outlier (right)

The diastole is divided into isovolumetric relaxation, early diastole, diastasis and late diastole (atrial contraction)[26]. In the MI, the early diastolic relaxation is the first stage to be altered, since it is a process that depends on energy[17,4-6], thus generating more dependency on atrial contraction to promote ventricular filling[28]. This can be observed in ECHO by the increased velocity of the A wave of the mitral flow. Such change consists of the first stage of diastolic dysfunction: the ADR, which is common in the early stage of most heart conditions[25,29].

The lateral a' wave presented higher values (9.19±3.04) than the mean of the national population (7.3±1.5)[30], and was inversely correlated with FC. In patients with with ADR and normal LV filling pressures, the a' wave is related to the systolic function of the left atrium[31]. According to Nagueh et al (2001), the compromised early diastolic relaxation increases the left atrial preload, leading to the increased muscle contraction, by the frank-Starling mechanism, which results in the increased a' wave velocity.

The found correlation can be related to the regions that are most compromised by the MI. Since the anterior and septal regions presented with compromised mobility for most subjects, the other regions can present with hyperkinesias as an attempt to attenuate the compromise of the ventricular function[32]. This compensation mechanism may have increased the velocity of the lateral a' wave. Therefore, this study, despite the low correlation magnitude, draws attention to the need for the early assessment of FC, especially among subjects who present with these echocardiographic characteristics, and also to the need for additional studies. Echocardiography is a routine procedure for these patients, being little explored from the functional capacity point of view.

According to ATS[12], the recent MI (up to 30 days) is a contraindication to perform the 6MWT; however, there is no evidence to prove such restriction[19]. On the contrary, the test is widely used in conditions of reduced FC, such as heart failure[16]. Besides, the 6MWT has been used with patients with recent MI, without intercurrences, in other studies[18,19]. The early assessment of FC guides the prescription of physical exercise in cardiac rehabilitation[15,20], thus contributing for the return to activities[33] and the improvement in quality of life[34].

Concerning the absence of 6MWT differences between groups with different DF of the LV, the type II error cannot be put aside, since the sample size was not calculated due to the absence of a clinically important reference in previous studies. Besides, the uneven number of patients per group and the lack of details on the used medication point to the need for new studies with the same focus.

In conclusion, even though no differences were observed between the groups with different degrees of DF, the found correlation indicates that the compromised early diastole increases the role of atrial contraction in the FC, reinforcing the need to assess these patients in the hospital. The physiological response to the 6MWT reinforces the viability of its use after recent MI.

ACKNOWLEDGEMENT

To Dr. Luiz Ricardo de Ataíde Castro, for the colaboration during the selection of patients.

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