

Functional Assessment of Coronary Grafts on Dobutamine Pharmacological Stress Echocardiogram

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Objective: To verify the sensitivity, specificity and diagnostic accuracy of dobutamine stress echocardiogram (DSE) when assessing the functional status of coronary grafts: sufficient (SUF) or insufficient (INS).

Methods: We carried out a prospective, observational study which included 25 patients submitted to coronary artery bypass grafting (CABG). The DSE and the coronary angiography were performed before the CABG and three months after the CABG. The left ventricle was divided into three territories per patient according to the three major coronary arteries: the anterior descending (AD), the circumflex (CX) and the right coronary (RC). Of the 75 possible territories, 54 were revascularized: 25 were specific to the AD artery and 29 of the CX/RC arteries. INS means luminal obstruction or occlusion greater than or equal to 50%.

Results: In 14 (26%) of the 54 revascularized territories the grafts were INS. The DSE detected ischemia in 16 (28%) territories; 10 of which had INS grafts. The DSE detected ischemia in 6 (15%) of the 40 territories whose grafts were SUF. Therefore, the DSE had a sensitivity of 71.4%, specificity of 85% and diagnostic accuracy of 81.4%.

Conclusion: The DSE is a diagnostic method with high specificity and diagnostic accuracy, and good sensitivity for the functional assessment of coronary grafts.

Key words: Myocardial revascularization surgery, dobutamine stress echocardiogram, myocardial ischemia.

The coronary artery bypass grafting (CABG) is effective to relief symptoms, extend the survival and improve left ventricular function in certain subgroups of patients suffering from coronary artery disease (CAD). The prognosis following CABG depends on several factors, especially graft patency, left ventricular function, and the presence of residual ischemia¹⁻³. This myocardial ischemia, even when not accompanied by angina, may influence the recovery of the function of the left ventricle and the prognosis of patients following CABG³.

The onset or persistence of myocardial ischemia following CABG may result from lesions and affect the graft itself (inadequate flow, obstruction and occlusion) or the native circulation (incomplete revascularization or new lesions). Approximately 3 to 12% of saphenous vein grafts occlude, with or without symptoms, in the first month following the CABG. Within the first year of the CABG, 15% of the saphenous grafts may be occluded, with an annual occlusion rate of approximately 1 to 2% between one and six years and of 4% between six and ten years. After ten years of the CABG only 60% of the venous grafts are patent, and only half is free from significant stenoses. Unlike venous grafts, arterial grafts particularly the left internal mammary artery (LIMA) have shown a high patency rate in the medium to long term. The LIMA patency rate is of almost 90% in ten years as compared to approximately 50% for saphenous grafts^{4,5}.

Some studies in the literature⁶⁻⁸ demonstrated that stress echocardiogram may be very useful to control patients treated with revascularization procedures in allowing the identification of myocardial ischemia and in assessing graft patency. The systematic application of this technique in the functional assessment of these patients following surgical revascularization provides information about the ventricular function and the existence and location of myocardial ischemia – crucial aspects in deciding on the indication of another coronariography following the revascularization surgery. Whether this method shows some limitation in this group of patients or not is not well documented since there are few studies about this technique.

Within this context, we carried out a study with the primary objective of verifying the sensitivity, specificity and diagnostic accuracy of dobutamine stress echocardiogram (DSE) in the functional assessment of coronary grafts.

Methods

This was a prospective, observational study which included 25 patients submitted to CABG in a benchmark institution for cardiology in the period between January 2002 and June 2003 and that met the inclusion criteria.

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The inclusion criteria were: indication for CABG; agreement to participate in the study by signing the consent term; coronary arteries with obstruction greater than or equal to 70% of the lumen of the vessel; asymptomatic stable patient after CABG; absence of limitations or counter-indications to dobutamine stress echocardiogram.

The exclusion criteria were: previous esternotomy; need for another concurrent surgery; presence of comorbidities which impede or increase the risk of another post-CABG coronary arteriography; chronic obstructive pulmonary disease which required bronchodilator; renal failure with serum creatinine above or equal to 2mg/dl; peripheral arterial disease with obstruction greater than or equal to 50% of the vessel lumen; liver failure; inadequate vascular access for the performance of another coronary arteriography; morbid obesity, with a body mass index greater than or equal to 40 kg/m²; obstructive atherosclerotic disease causing obstruction equal to or greater than 50% of the left coronary main or equivalent of left coronary main (obstructive atherosclerotic lesion greater than or equal to 70% proximal of the anterior descending artery-DA and the circumflex artery-CX); pre-operative limitations or clinical counter-indication for dobutamine stress echocardiogram; maintenance in stable angina class III or IV according to the Canadian Cardiology Society after therapeutic optimization; lack of clinical stabilization in acute coronary syndrome; inadequate echocardiographic window; severe arterial hypertension; significant atrial or ventricular arrhythmia; severe valvulopathy; hypertrophic cardiomyopathy.

Dobutamine stress echocardiogram – Two DSEs were performed: one before the CABG and the other three months after the CABG. The average timeframe between the DSE and the CABG was 28.2 days and between the CABG and the DSE was 115.5 days. All the DSEs were performed by the same physician, one with great experience in the procedure. For the echocardiographic analysis the left ventricle was assessed from four standard echocardiographic views: longitudinal parasternal, cross-sectional parasternal, four-chamber apical and two chamber-apical. The left ventricle was divided into sixteen segments, according to the guidelines of the Brazilian Society of Cardiology and the American Society of Echocardiography⁹. This division correlates each one of these segments with the three major arteries of the heart: anterior descending artery (AD), right coronary artery (RC) and circumflex artery (CX). Therefore the AD artery irrigates nine segments (basal, medial and apical anterior; apical, medial and basal anterior septum; apical and mid-inferior septum; apical lateral and inferoapical); the CX artery irrigates five segments (basal, medial and apical lateral; medial and basal posterior); and finally the RC artery irrigates six segments (apical, medial and basal inferior; basal inferior septum; medial and basal posterior).

Systolic thickening of the left ventricle was graded according to motility scores for each segment: (1) normal; (2) hypokinetic; (3) akinetic; (4) dyskinetic.

The stress echocardiogram was performed with dobutamine and, if necessary, with atropine. For the test to be considered effective, the patients had to reach 85% of the maximum heart frequency for their age, observe signs

of myocardial ischemia or reach the end of the infusion protocol. The electrocardiogram and the blood pressure were continuously monitored, and venous access was maintained during the whole test. The dobutamine infusion was administered in increasingly large doses from 5 to 40 µg/kg/min, with increments of 5µg/kg/min every three minutes. If, during the maximum dose, the patient failed to reach 85% of the maximum heart frequency, atropine (0.5 to 1 mg intravenously) was administered to this end. The interpretation of the test was based on the simultaneous presentation of images which allowed us to compare each segment of the myocardium on the echocardiogram at rest and in the different phases of the dobutamine infusion; the images were recorded in video for review. The comparison of the segments at rest with the segments under stress determined the type of ischemic response when there was worsening of contraction during dobutamine infusion. The location of motility changes in the segments on the stress echocardiogram was correlated with the patency of grafts in each revascularized territory.

A coronary arteriography was performed pre-operatively in the hemodynamics laboratory and after three months of the CABG. The average timeframe between the coronary angiography and the CABG was 60.3 days and between the CABG and the second coronariography was 111 days. Both coronary arteriographies were performed by doctors with great experience in this procedure and analyzed by one specialized physician who was unaware of the management and the type of surgery performed. In the coronary arteriography, the following items were analyzed: the number of native vessels affected, the number of sufficient arterial and venous grafts (without lesions or with obstructive lesions smaller than 50% of the graft lumen) and insufficient (occluded or with obstructions equal to or greater than 50% of the graft lumen), and the presence of collateral circulation. The severity of lesions in the native circulation was classified as mild (obstructions smaller than 50% of the vessel lumen), moderate (obstructions equal to or greater than 50% and smaller than 70% of the vessel lumen) and severe (obstructions equal to or greater than 70% of the vessel lumen).

The CABG was performed with a standardized surgical technique according to the institution's routine protocols.

The statistical analysis was carried out with the following methods: to compare quantitative data (numerical variables) between two groups we used the Mann-Whitney test. To compare qualitative data we applied Fisher's exact test.

To verify the existence of variation between the pre-operative and the post-operative periods in terms of numerical variables we used the Wilcoxon non-parametric test. To analyze the variation between qualitative variables we applied the McNemar test.

The criterion for determining significance was a level of 5%.

Results

Twenty-five patients with a mean age of 58.4±7.8 years (42-72 years old) were analyzed. Of these, twenty-two were male (88%) and all were white. On clinical and anatomical

diagnosis at hospitalization 80% had stable angina, 20% had unstable angina, 48% had CAD in three vessels, 44% in two vessels and 8% in one vessel; all had the DA artery affected in that in 68% it was the proximal AD that was affected. When analyzing risk factors and co-morbidity, 76% had arterial hypertension, 28% had diabetes mellitus, 32% were smokers, 56% had dyslipidemia, 12% had cerebral vascular disease, 20% had peripheral arterial disease and 68% had had AMI.

Twenty-four LIMA grafts were used for the anterior descending artery, 6 grafts from the radial artery and 37 saphenous grafts. The total number of grafts per patient was 2.7 ± 0.6 (1-4). The ATIL was patent and sufficient in fifteen patients (62.5%). In five grafts (20.8%), the LIMA was patent and insufficient. In four grafts (16.7%) the LIMA was occluded. The radial artery was patent and sufficient in five grafts used (83.3%) and occluded in one (16.7%). The saphenous graft was patent and sufficient in thirty-two grafts used (86,4%) and occluded in five (13.5%).

In the analysis of the 25 patients, we observed a significant shift in the pattern of ischemic response when comparing the pre-operative DSE with the post-operative DSE. There was a significant decrease in ischemic response from the pre-operative level (92%) to the post-operative level (56%) as shown in figure 1.

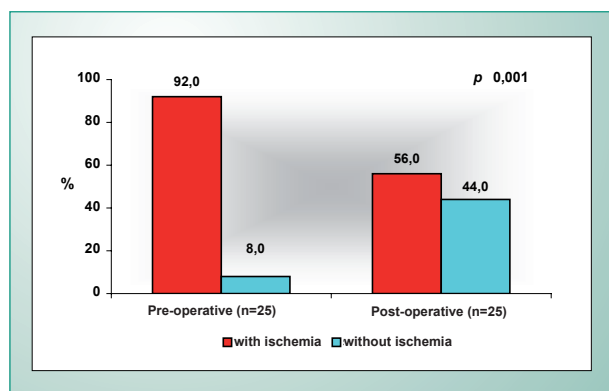


Fig. 1 - Ischemic response on pre and post-operative stress echocardiogram.

In the analysis of the 25 patients, we observed a significant association ($p= 0.011$) between the presence of myocardial ischemia post-operatively and the insufficient graft. Of the 25 revascularized patients, 13 (52%) had sufficient grafts and 12 (48%) had insufficient grafts. The DSE detected myocardial ischemia in 14 (56%) patients in the post-operative period; in 10 of these the grafts were insufficient. The DSE detected myocardial ischemia in 4 (30.8%) of the 13 patients whose grafts were insufficient. Therefore, when analyzed on a per patient basis, the DSE showed a sensitivity of 83.3%, a specificity of 69.2% and a diagnostic accuracy of 76% as shown in figure 2.

Of the 75 possible territories in the 25 patients, 54 were revascularized and analyzed: 25 were specific to the AD artery and 29 were specific to the CX/RC arteries. In the analysis of the revascularized territories we observed a

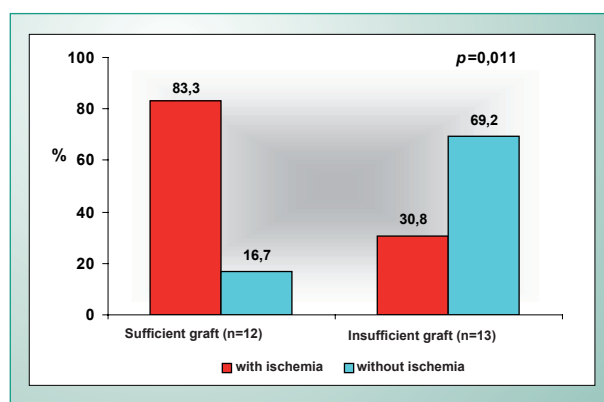


Fig. 2 - Myocardial ischemia and graft functional status (per patient).

significant association ($p=0.001$) between the presence of post-operative myocardial ischemia and insufficient graft. As regards the 54 revascularized territories, in 14 (26%) the grafts were insufficient and in 40 (74%) they were sufficient. The DSE detected myocardial ischemia in 16 (28%) territories; in 10 of them the grafts were insufficient. The DSE detected ischemia in 6 (15%) of the 40 territories whose grafts were sufficient. Therefore, the DSE presented a sensitivity of 71.4%, specificity of 85% and diagnostic accuracy of 81.4% as shown in figure 3.

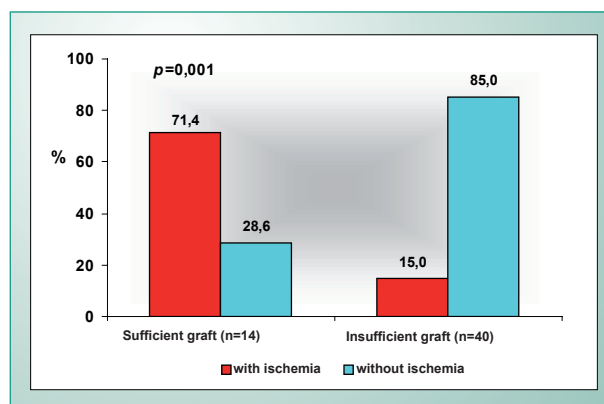


Fig. 3 - Myocardial ischemia and graft functional status in 54 revascularized territories.

Discussion

According to this study, in the analysis of the 25 patients there was a significant association ($p= 0.011$) between the presence of myocardial ischemia on post-operative stress echocardiogram and insufficient graft. The group of patients with insufficient graft presented myocardial ischemia on post-operative stress echocardiogram at a significantly higher rate of (83.3%) as compared to the group with sufficient grafts (30.8%). The stress echocardiogram demonstrated to have good sensitivity (83.3%), moderate specificity (69.2%) and diagnostic accuracy of 76.0% in the assessment of the functional status of grafts per patient.

When analyzing the presence of myocardial ischemia revealed by the DSE post-operatively and of the graft functional status in the 54 revascularized territories, we observed that

those territories with insufficient grafts presented a significantly higher rate of post-operative myocardial ischemia than those with sufficient grafts (71.43% as compared to 15.9%; $p=0.001$). The study showed that the DSE is a diagnostic means with moderate sensitivity (71.4%), high specificity (85%) and diagnostic accuracy (81.4%) for the functional assessment of grafts in revascularized territories.

Elhendy et al⁶ studied 50 patients submitted to dobutamine stress echocardiography and to a coronary arteriography three months after the CABG. The sensitivity was 78%, specificity was 89% and diagnostic accuracy was 82% for the detection of myocardial ischemia in territories with vascular impairment in the grafts or in the native circulation.

Crouse et al⁷ studied 125 patients who had been submitted to surgical revascularization and then to exercise stress echocardiography and subsequently to a follow-up coronariography post-operatively. The sensitivity to detect ischemia in territories with vascular impairment in grafts or in the native circulation was 98%; the specificity was 92% and the positive and negative predictive accuracy were 99% and 86% respectively. Kafka et al⁸ confirmed these data in another study carried out with 182 patients submitted to exercise stress echocardiography and coronariography after the CABG and obtained a positive predictive value of 98% and a negative predictive value of 81% for vascular impairment in the grafts or in the native circulation.

The results of our study are comparable with those found in the literature. However, Elhendy et al included symptomatic patients (70%) and asymptomatic patients and analyzed the functional status of the grafts and of the native circulation. Kafka et al and Crouse et al found better results as regards diagnostic accuracy measurements in the assessment of the impairment of grafts and of the native circulation, but part of the patients were symptomatic (30% and 60% respectively) which probably contributed to the better results obtained.

In our study we analyzed only the functional status of grafts, in that the non-revascularized territories or the territories with new lesions in the native circulation contributed to false positive results and to the decrease in the specificity and diagnostic accuracy when we analyzed [the results] on a per patient basis. When we analyzed the 54 revascularized territories and excluded the 21 non-revascularized territories we observed that specificity (69.2% as compared to 85.0%) and diagnostic accuracy (76.0% as compared to 81.4%) improved due to the decrease in the frequency of false positives (30.7% as compared to 15.0%).

Although the application of this method after the CABG in theory has the disadvantage that many patients have segmental abnormalities at rest which could confound the interpretation of results (increase of false positives), the findings in our study as regards diagnostic accuracy measurements are comparable to those reported for non-CABG patients. Therefore there is no limitation for the method as regards this group of patients.

Since the DSE is widely used in most hospitals because it is a simple and low-cost procedure as compared to other methods of assessment of myocardial ischemia, such as myocardial scintigraphy, positron emission tomography and stress magnetic resonance imaging constitute a method that may be used during the clinical follow-up of patients to assess the presence of myocardial ischemia, the functional status of grafts and the efficacy of CABG. We should analyze the results of the stress echocardiogram per territory, correlating it with the presence of coronary grafts for this region. The positivity of the test in revascularized territories, even in asymptomatic patients, allows the identification of patients with a moderate likelihood of having insufficient grafts in that territory, and when negative, with a high likelihood of having sufficient grafts in that territory.

Potential Conflict of Interest

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

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