

Prognostic Value of the Doppler Index of Myocardial Performance in Postoperative of Coronary Artery Bypass Surgery

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Objective: Myocardial Performance Index (MPI) obtained by Doppler echocardiography for the non-geometrical evaluation of systolic and diastolic function has been described as a method for prognostic evaluation in patients with acute myocardial infarction (AMI). Using the same condition, the objective of this study was to evaluate the predictive value of MPI for cardiovascular complications in patients at low risk during the postoperative period of CABG.

Methods: Eighty patients submitted to CABG with adequate left ventricular function in the preoperative period were studied, with MPI measured during the first hours postoperatively. Patients were followed until hospital discharge. Statistical analysis included Chi-Square test, Student t test, Mann-Whitney test, and estimation of relative risks with 95% confidence intervals, sensitivity and specificity plus a ROC curve.

Results: The data were evaluated by two independent observers blinded to the clinical data with non-significant intra and interobserver variability. $MPI=0.43$ was found as the cutoff point, considering patients with a higher probability of postoperative events those who had MPI above 0.43. The relevant events for analysis were AMI (RR 0.87 ci 0.21-3.65), atrial fibrillation (RR 0.65 ci 0.24 – 1.76), other arrhythmias (RR 1.51 ci 0.36-6.33), LV dysfunction (RR 1.74 ci 0.32-9.88), with no association between patients with $MPI>0.43$ and the occurrence of these events.

Conclusion: No association was found between MPI and cardiovascular complications and longer hospital stay in this group of patients, and this index was considered not adequate as an isolated predictive method.

Key words: Coronary artery bypass graft, low risk, morbidity, myocardial performance index (MPI) and prognostic outcome.

The post-surgical morbimortality of coronary artery bypass graft (CABG) surgery is of great interest, resulting in several protocols of post-operative management and risk models aiming at decreasing cardiovascular complications¹.

The presence of left ventricular dysfunction and cardiac failure in the postoperative period of CABG has been considered one of most important independent predictive factors of surgical mortality²⁻⁵, with an association between the severity of the left ventricular dysfunction and risk of complications (4% to 10% for moderate to severe ventricular dysfunction)³.

Cardiac surgery complications in patients with adequate left ventricular function in the pre-operative period have a low prevalence²; therefore, they are hardly studied. In this group, the identification of alterations in the overall function of the left ventricle in the immediate post-operative period would allow early interventions, resulting in lower surgical morbimortality^{6,7}.

Non-invasive measurements of time intervals used for the assessment of the systolic and diastolic functions were proposed by Mancini⁸ through phonomechanocardiography and reintroduced by Tei et al⁹ in 1995 and showed to be easily obtained by conventional Doppler, with time intervals, combining assessment of the systolic performance and the diastolic performance of the left ventricle (LV). This index can be easily obtained and reproduced, regardless of the ventricular geometry, which makes it adequate for the assessment of the overall ventricular function in several clinical situations^{10,11}.

The index is defined as the sum of the isovolumetric contraction time and isovolumetric relaxing time divided by the ejection time through the Doppler analysis at the mitral inflow and the left ventricular outflow velocity and time¹¹⁻²⁶, being considered a possible assessment factor for total cardiac function and cardiac prognosis predictor^{10,12,13}.

Several studies have evaluated MPI in patients with acute myocardial infarction, miocardiopathy, and valvar disease among others, and the index presented an elevated prediction power for the development of unfavorable outcomes^{10,13-18,26}.

The main objective of this study is to establish the prognostic value of the myocardial performance index (MPI) for cardiovascular complications (major events: ischemic cardiopathy (IC), AMI, arrhythmia and death) during hospital stay and eventual increase of duration of post-operative unit stay due to cardiovascular complications, in patients with adequate left ventricular function in the pre-operative period.

Methods

Eighty patients (53 males and 27 females) were prospectively studied while staying at Instituto de Cardiologia – Fundação Universitária de Cardiologia do RS in order to undergo CABG, from February to September 2003. The study was approved by the Institution Review Board and all patients read and signed the free informed consent term.

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The patients were selected at the pre-operative period (1 day before the surgery) according to the following inclusion criteria: isolated CABG, EF \geq 50% (hemodynamic evaluation, echocardiography (Simpson) or through nuclear medicine) and sinus cardiac rhythm.

Of the 91 patients initially eligible during the study period, 11 were excluded according to the following criteria: limited echocardiographic windows (3); refusal to sign the informed consent term (1); absence of EF measurement at the pre-operative exams (4); and non-performance of echocardiography before hospital release (3).

The index assessment was carried out within the first 24 hours of the post-operative period (immediate period) at the ICU. The equipment utilized was HP Sonos 100 with a 2.5 MHz transducer. The assessment was carried out by the researching nurse or echocardiographer, with the patient on dorsal or lateral decubitus position, depending on the position of the thorax drains used in the post-operative period after cardiac surgery.

The pulsed Doppler measurements were obtained while guided by bidimensional images, with concomitant electrocardiographic tracing, recorded in VHS videotapes, digitized and analyzed in a dedicated workstation, using an echo offline program for measurements and posterior analysis.

With the Doppler sample-volume positioned on the ventricular portion of the left ventricle inflow tract, in a four-chamber cut, images of the flow velocity were obtained, from the opening to the closing of the mitral valve. The ventricular outflow was obtained in a five-chamber cut, with the pulsed Doppler sample-volume positioned below the aortic valve. Time intervals at the Doppler were calculated in a working station (offline) as shown in Figure 1.

The "a" interval from the opening to the closing of the mitral valve is equal to the sum of the isovolumetric contraction time with the isovolumetric relaxation and ejection time. The "b" interval is the time of the left ventricular ejection. Thus, the sum of the isovolumetric contraction and relaxation

time is obtained by subtracting "b" from "a". The index that combines the systolic and diastolic functions was calculated as (a - b)/b (Fig. 2).

The measurements of the "a" and "b" intervals were carried out three times, independently for each interval, and afterwards, the means were calculated by means of an Excel worksheet.

All images were analyzed by an experienced echocardiographer who also carried out all repeated measurements, being blinded to patients' clinical data and the results of the first measurements, for posterior interobserver analysis.

After the exam, a proper analysis file with patients' data was filled out, and patients were followed until hospital release. During this procedure, post-operative complications were observed, as well as use and time of use of inotropic drugs, duration of ICU and

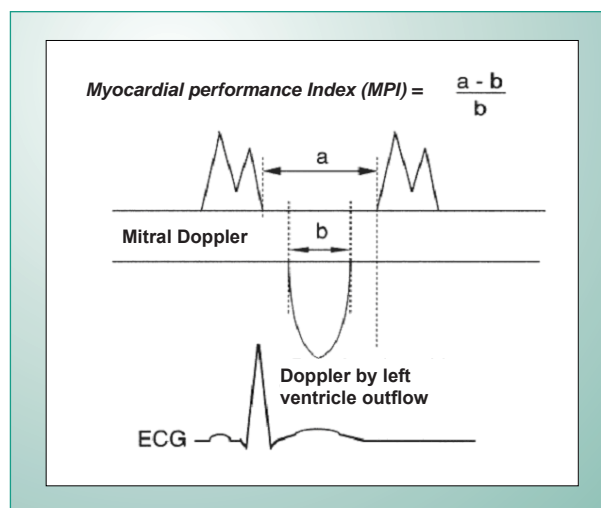


Fig. 2 - Diagram representation of the mitral and aortic Doppler measurements to determine MPI. The index is defined as (a - b)/b, with "a" being the interval from the opening to the closing of the mitral valve, and "b" the time of the left ventricular ejection.

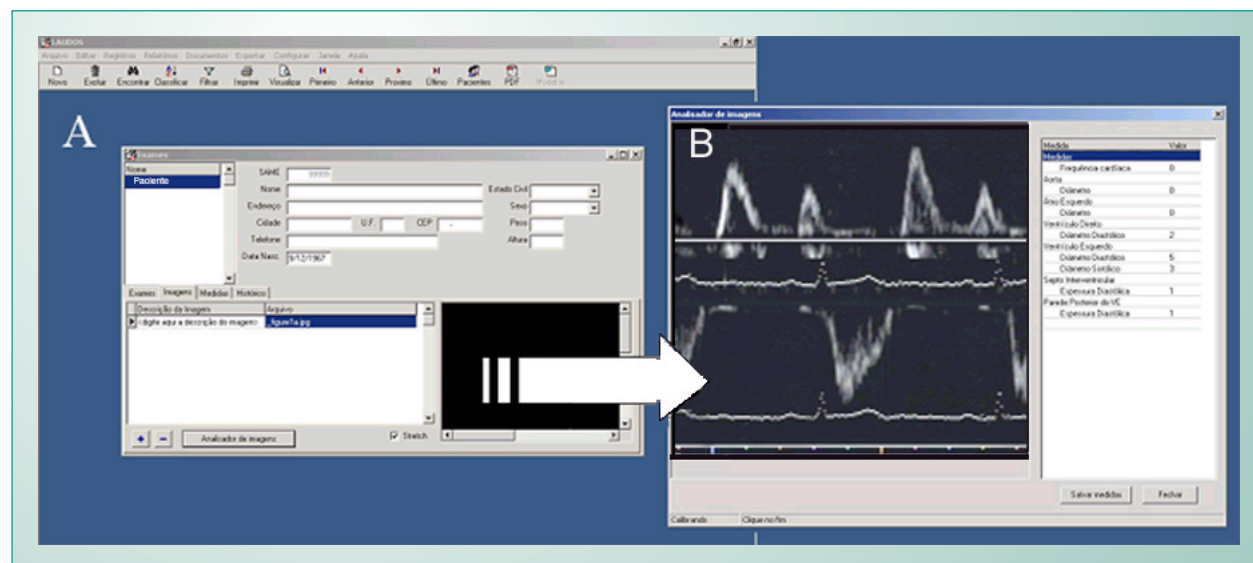


Fig. 1 - Workstation screens (echo offline) in which A show patient's identification data. In B, the calibration was performed after the corresponding image acquisition, followed by the measurements of "a" and "b" intervals (three different cycle measurements were used for each measurement).

hospital stay and control exams (ECG and thorax x-ray), with the addition of a complete echocardiographic exam, up to 24 hours prior to release from the Cardiographic Method Unit, according to the Service routines. The exam results were included in the patient's file and a copy was sent to research.

The criteria for AMI diagnosis were the presence of new Q waves at the ECG and enzymatic alterations (CK-MB > 40 mU/L and troponin > 3.5 ng/mL).

For the diagnosis of atrial fibrillation and other arrhythmias, the criteria adopted were those of continuing cardiac monitoring and confirmation by ECG.

For the diagnosis of LV dysfunction, the criteria adopted were those of the patient's hemodynamic evaluation (NYHA functional classification) confirmed by echocardiography, and decreased ejection fraction by comparing pre and post-operative measurements.

The confirmation of pulmonary congestion was achieved by the analysis of the results of the radiological exams. The statistical analysis was carried out by the software SPSS 11.0 (Chicago Illinois Software).

The data were described as means and standard deviations (SD) or medians and interquater intervals 25-75 for the continuing variables and ratios for the categorical variables.

Student's *t* test was used to compare the index means in patients with and without events. The index was dichotomized according to its mean. The Chi-square test was used to assess the association between the dichotomized index and the events, with the additional calculation of relative risks (RR) and respective confidence intervals (CI) of 95%.

The Mann-Whitney test was used to compare duration of hospital stay and use of drugs with MPI categories. A *p* value ≤ 0.05 was considered statistically significant.

Additionally, sensitivity and specificity for different index cutoffs were calculated and a ROC (receiver operator characteristic) curve was constructed with SPSS 11.0 command.

Resultados

The 80 patients with ischemic cardiopathy who underwent surgical myocardial revascularization were 32 to 83 yrs of age and did not present significant valvar disease. All surgeries were elective ones with extracorporeal circulation (ECC). The groups were divided considering the cutoff as the index mean value (0.43).

The characteristics of the sample are summarized in Table 1 (total of sample)

Figure 3 shows a ROC curve for the different values of MPI regarding the occurrence of major events, being impossible to identify, through the curve, a point of better balance between sensitivity and specificity.

For the analysis of events in the post-operative period, Group A ≤ 0.43 and Group B > 0.43 were considered. The characteristics of the sample from these groups are shown in Table 1 (Groups A and B).

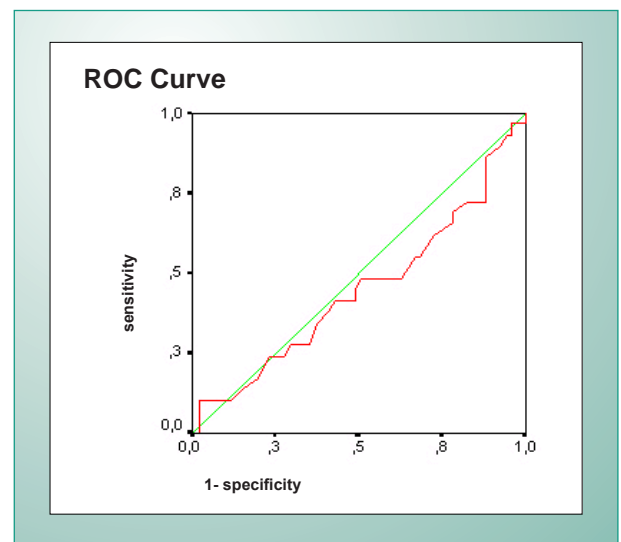


Fig. 3 - MPI ROC curve for major events.

Variables	Total of sample	Group A (IPM ≤ 0.43)	Group B (IPM > 0.43)	Value of <i>p</i> ****
n	80	43	37	
Age	61 ± 9.9	62 ± 9.9	60 ± 10	0.276**
Male/female*	53/27	29/14	24/13	0.995***
Arterial Hypertension *	56 (70%)	31 (72%)	25 (67%)	0.844**
Diabetes Mellitus*	26 (32%)	9 (21%)	17 (46%)	0.022**
Previous AMI*	25 (31%)	11 (25%)	14 (38%)	0.348**
Smoker*	42 (52%)	22 (51%)	20 (54%)	0.973**
Alcohol consumption*	4 (5%)	3 (7%)	1 (3%)	0.619**
Dyslipidemia*	13 (16%)	6 (14%)	7 (19%)	0.766**
Obesity*	3 (4%)	2 (5%)	1 (3%)	1.000**
Previous PTCA*	3 (4%)	0	3 (8%)	0.094**

n: number of patients; *history of; ** Student's *t* test; *** Pearson's chi-square test; **** for comparisons between groups A and B.

Table 1 - Clinical characteristics of 80 patients in the post-operative period of CABG admitted at the ICU

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The mean difference in the measurement of the MPI between the two observers (nurse and echocardiographer) was 0.0046, which was considered non-statistically significant.

We did not observe any significant differences regarding major events between the groups. The diagnostic characteristics of the index (> 0.43) for major events were: sensitivity of 0.41 (0.14 – 0.68) and specificity of 0.51 (0.32 – 0.70). The index did not show significant associations with any of the considered events, when analyzed under a continuous as well as categorized form. The RR and respective 95% CI are shown in Table 2.

It is noteworthy the low prevalence of these events in the total sample (35%). The ejection fraction in the post-operative period, when compared to the pre-operative one, was decreased in 77% of the patients from Group A and 84% of the patients from Group B ($p=0.64$). Another variable analyzed was pulmonary congestion, through radiological documents obtained at the recovery room and at hospital release, with pulmonary congestion being observed in 29% ($n=23$) of the patients, of which only 39% ($n=9$) belonged to Group B.

One of the subjective variables analyzed was dyspnea in the post-operative period, being referred by 19% ($n=15$) of the patients, of which 47% ($n=7$) presented MPI > 0.43 (Group B).

Regarding the use of inotropic drugs (dopamine, dobutamine, noradrenaline), 75% of the patients ($n=60$) used them at the immediate post-operative period, of which 47% ($n=28$) belonged to Group B and 53% ($n=32$) to Group A. There was no difference between the groups regarding the number of patients who did not use any of these drugs.

The analysis of time of inotropic drug use and duration of hospital and ICU stay did not show a significant difference between the groups. Regarding the time of inotropic drug use, the mean time was 1.5 days in Group A and 1.2 days in Group B ($p=0.945$). As for the duration of ICU stay, the median was 2 (1.88; 2.67) and 2.25 (1.70; 3.96) days and the mean duration of hospital stay was 8 ± 1.3 and 9 ± 5 days ($p=0.999$), respectively, for Groups A and B.

None of the patients needed mechanical support (intra-aortic balloon/bio-pump) in both groups in the post-operative period, and only 2 patients (both from Group A) needed more than 24 hours of mechanical ventilation, being still intubated as the exam was being carried out (performed during the first 24 hours).

Discussão

CABG is a major procedure, highly disseminated around the world, with its complications being related to the pre-operative situation and particularly to extra-corporeal circulation (EEC). Some studies show a decrease in complications when CABG is performed without ECC^{4,5}. The prognostic evaluation of the patients undergoing CABG through pre-operative clinical parameters, present well-defined usefulness and understanding^{6,7}. However, in certain situations, patients classified as being high-risk present low post-operative morbidity, and patients with low scores of pre-operative risk have a complicated post-operative evolution, related to intra-operative factors that interfere directly on the patient's evolution⁶. This fact has become of interest for several researchers, considering all the variables that can identify high-risk patients at an early stage.

The MPI has been considered a good predictor for adverse results in several cardiac diseases, such as valvar insufficiency¹³⁻¹⁵, miocardiopathies¹⁶, acute myocardial infarction^{10,17,18,20-22} and cardiac toxicity to anthracycline²³, with no reference in literature of MPI as a predictor for events in the immediate post-operative period after myocardial revascularization surgery in individuals with previous adequate systolic function.

Another advantage of this index, in addition to being easy to obtain and its low cost, is the possibility of measuring it by a professional who has received a brief training in echocardiography¹⁸. In our study, similarly, we did not find any difference between the measurement carried out by the nurse trained for such task and the echocardiographer with broad experience.

The MPI was altered (> 0.43) in 37 patients (Group B) in whom the follow-up by observation did not show worsening in the clinical evolution; additionally, the number of events in this group was not increased, as was expected, when compared to Group A.

The number of complications in the post-operative period of the myocardial revascularization surgery in patients with adequate ventricular function was low with absence of mortality, similar to the literature data, where the mortality rate is around 0.2%². As a consequence, the total duration of hospital stay was similar to that reported by other studies (8.3 and 7.3 days)^{24,25}.

Although the incidence of atrial fibrillation was elevated in this cohort, the patients' post-operative evolution was adequate,

Major events	Group A MPI ≤ 0.43	Group B MPI > 0.43	RR	95%CI
AMI	9.3%	8.1%	0.87	(0.21- 3.65)
Atrial fibrillation	20.9%	13.5%	0.65	(0.24- 1.76)
Other arrhythmias	9.3%	10.8%	1.51	(0.36- 6.33)
LV dysfunction	4.7%	8.1%	1.74	(0.31- 9.88)
All CV complications	58.1%	54.1%	0.93	(0.63- 1.37)

IAM: acute myocardial infarction; LV: left ventricle; CV: cardiovascular; other arrhythmias (atrial flutter, frequent ventricular extrasystoles and AV blockade).

Table 2 - Association between major events and MPI values

without other resulting complications and without an increment of duration of hospital stay, with the sample mean being 8 and 9 days (groups A and B), similar to what is reported in literature^{5,24}. The MPI was not a predictor of these events.

In opposition to literature data, this study showed that the MPI was not effective in the early identification of patients with the possibility of complications in the post-operative period.

It was initially postulated that such results can result from the study limitation due to the small sample size and the low number of complications in the observation period. However, other considerations must be made regarding the studies that utilized the MPI as a predictor index for events.

The study by Mukhaini et al¹⁵, which utilized the index for adverse results in mitral valve surgeries, concluded that the MPI was a potentially useful index in predicting perioperative death or the development of cardiac insufficiency. The MPI cutoff value for these authors was 0.7 and, in the pre-operative period, 63.6% of the patients had a functional class > 2 of the NYHA, differing from our study, in which the functional class or LV systolic function was preserved in the pre-operative period.

The study by Poulsen et al¹⁰ in patients with AMI showed the usefulness of the MPI in identifying the patients with higher likelihood to develop cardiac insufficiency. The study compared patients at the acute phase of AMI to a control group consisting of healthy individuals, showing a significantly higher MPI in the case group. The sensitivity of the MPI was 100% with a specificity of 33% for events.

Moller et al¹⁸ carried out the first large study that verifies the efficacy of MPI as a predictive value of mortality in patients post-AMI. Of the 799 patients, 197 died during the 34-month follow-up, with 66 of them having normal EF and altered MPI, in contrast to only 19 deaths among the patients with normal MPI (< 0.46). The study showed that the MPI was the best independent predictive factor, better than the isolated systolic function in the prognostic evaluation of the AMI. The infarctions described in these studies presented a larger extension than those observed in the post-operative period of the myocardial revascularization surgery, which occurred in 8.8% of the individuals in our series, without a severe involvement of the systolic function.

In the experimental studies by Curi et al²¹ 33 female Wistar rats were submitted to AMI of different extensions and compared to false-operated rats (control group). The analysis of the MPI was carried out 6 weeks after the intervention, showing a higher index in moderate and severe infarctions, but not in animals with mild infarctions, which did not differ from those in the control group. In our series, the perioperative infarctions might correspond to the small infarctions obtained experimentally, with no significant difference, therefore, between groups A and B.

More recently, Hole et al¹⁷ carried out another study to assess whether the alterations in the MPI would be related to alterations in other echocardiographic parameters after AMI, and what would be the impact of the index as an independent predictive factor during a 2-year follow-up. Similarly to our study, the MPI was not considered an independent predictive value for changes in the systolic function.

The contradictory findings among the initial studies and the latter ones are probably due to the natural history of the assessment of a new diagnostic test. Initially, the tests are assessed under extreme conditions, distant from the usual clinical practice. When the test starts to be evaluated in situations that are closer to reality, usually the results are less evident, decreasing its clinical usefulness. In the present study, the MPI was assessed in a homogenous population of patients with normal EF, which contributed to reduce the discriminatory capacity of the test.

Thus, the possibility to identify, among patients with normal left ventricular function in the pre-operative period of myocardial revascularization surgery, those with high risk of complications in the postoperative period through the MPI was not achieved. Also, patients with a longer duration of hospital stay were not identified by this method. Further studies with larger numbers of patients are necessary to verify whether or not the index is effective as an isolated prognostic method in the post-operative period of myocardial revascularization surgery.

Potential Conflict of Interest

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

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