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Prognostic value of right ventricular myocardial performance index in patients undergoing coronary artery bypass surgery

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Abstract

Background: Right ventricular myocardial performance index (RVMPI) is a Doppler–derived parameter of non-geometrical ventricular function that measures both systolic and diastolic functions of the right ventricle. The aim of this study is to compare prognostic value of RVMPI with global RV function in patients undergoing Coronary Artery Bypass Graft (CABG).

Methods: In a longitudinal study, 100 eligible patients who underwent CABG for coronary artery diseases were studied from March 2004 to September 2006. Global RV function and RVMPI changes were measured serially by Doppler echocardiography after surgery. Patients were divided into 2 groups. In group A, LVEF was $\leq$ 40% and in group B, LVEF was >40%. Patients were followed for four months after hospital discharge. Statistical analysis included chi-square test, student t–test or one-way analysis of variance (ANOVA).

Results: We studied the incidence of atrial fibrillation (AF), post-operative myocardial infarction, pericardial and pleural effusion, infection, readmission and also ventilation time and ICU duration. Global RVEF and RVMPI were not related to the incidence of post-operative AF rhythm, myocardial infarction, pericardial effusion, pleural effusion, infection and readmission in both groups. In group B, RVMPI had more prognostic effect on ventilation time and ICU duration, but this effect was not seen in group A. In group B, global LVEF and LVMPI had more prognostic effect on ventilation time and length of ICU stay in comparison with those in group A.

Conclusion: In group B (EF>40%), RVMPI had the most prognostic effect on estimation of ventilation time and ICU stay duration, but in group A (EF $\leq$ 40%), LVMPI had the most prognostic effect on them.

Keywords: right ventricular myocardial performance index, coronary artery bypass surgery.

Introduction

Right ventricular (RV) function plays an important role in survival and in the post-operative period of patients undergoing cardiac surgery. RV systolic function is routinely evaluated by RVEF or RV fractional area change (RVFAC). RV myocardial performance index (RVMPI) also applies for evaluation of RV systolic and diastolic function. For the right heart, this index was validated by transthoracic echocardiography for congenital heart disease [1,2] and chronic respiratory diseases [3]. RVMPI is the strongest predictor of adverse outcome in patients with primary pulmonary hypertension [4]. The RVMPI increases significantly when there is RV infarction [5]. Although RV dysfunction can occur after conventional coronary artery bypass surgery, RVMPI

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has not been evaluated as a prognostic factor in this setting. The aim of this study is to evaluate the prognostic role of RVMPI in patients undergoing CABG.

Methods

Among 136 consecutive patients, we studied 100 eligible patients (78 men and 22 women). The selected patients are those who had coronary artery disease without significant valvular disorders.

Echocardiographic data were collected at three intervals: before, and one month and four months after surgery. Two dimensional and Doppler echocardiography were performed on a Megas-Esaote echocardiography machine with 3.5 MHz electronic probe. Five consecutive beats were measured and averaged for assessment of each parameter.

The crescentic shape of the right ventricle makes it difficult to mathematically model it, unlike the left ventricle. Assessment of RV systolic function includes calculation of RVEF or RV fractional area change (RVFAC). The right ventricular fractional area change is calculated as the RV end-sistolic area (RVEDA) minus the RV end-diastolic area (RVESA) divided by the RVEDA (RVFAC = [RVEDA-RVESA]/RVEDA). The ESA and EDA of the right ventricle can be measured by planimetry in the apical 4-chamber view (in trans-thoracic echocardiography) or in the mid-esophageal 4-chamber view (in trans-esophageal echocardiography). Few studies have used the RVFAC to evaluate RV systolic function in coronary surgery. RVFAC under 35% before coronary bypass graft surgery is associated with increased post-operative mortality. But the range of normal value for the RVFAC is very large, from 40 up to 74% which reduces its clinical use [6].

RVEDV and RVESV are required to calculate the RVEF. Measurement of RV volumes is difficult because of the complex shape of the right ventricle. Several models of the right ventricle have been proposed. Using a formula based on a crescentic model, the RV volume can be calculated as RV volume= 2/3 × (RV area × RV long axis) [7], where the area is measured as previously described in the 4-chamber view, and the long axis as the distance between the lateral annulus of the tricuspid valve and the pulmonary valve. Making these measurements in end-diastole and end-systole, allows one to calculate the RVEDV and RVESV as well as the RVEF (RVEF=[RVEDV - RV ESV]/ RVEDV).

The myocardial performance index (MPI), first described by Tie et al in 1995, allows for a combined evaluation of the systolic and diastolic function [8]. The MPI is a ratio of the sum of the two isovolumic intervals (IVRT and IVCT) divided by the ejection time (ET) (RVMPI=[RV IVRT+RV IVCT]/ET). For calculation of this index, Doppler velocity recordings of tricuspid inflow and pulmonary artery outflow are required (Fig.1).

We also measured right atrial volume (RAV) and pulmonary artery pressure in these patients. The cohort study enrolled those who had an uneventful follow-up with an analyzable four-month follow-up echocardiography. Continuous variables were expressed as mean +/-SD. Normally distributed variables were tested by two tailed student t–test for paired or unpaired data, as appropriate by one-way analysis of variance (ANOVA) for more than two independent groups of data. The categorical variables were compared by chi-square and Fisher exact test. Correlation between two continuous variables was tested by ANOVA for repeated measures. A P-value less than 0.05 was considered statistically significant.

Results

100 patients with coronary artery disease who underwent CABG were 37 to 73 years old and did not have any significant valvular diseases. All surgeries were elective ones. The groups were divided considering the cut-off value EF (>40% and $\leq$ 40%). For analysis of events, group A was considered with EF $\leq$ 40%

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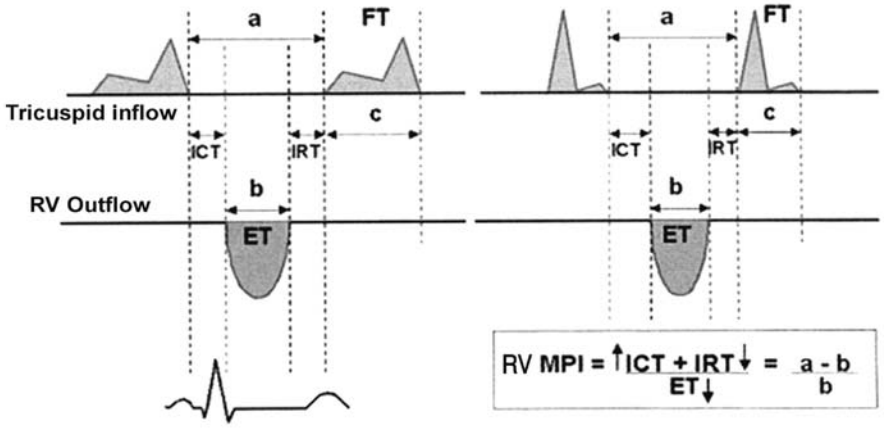


Fig.1. Derivation of the RV MPI and from Doppler tracings of Tricuspid inflow and RV outflow a=time between filling periods, which equals the duration of Tricuspid regurgitation (TR), when present; b=ejection time (ET); c=filling time (FT). The sum of isovolumic contraction time (ICT) and isovolemic relaxation time (IRT) can be obtained by the subtraction of b from a.

and group B with EF>40%. The characteristics of the studied factors from these groups are shown in table 1. These data related to prior stage of surgery (phase 0).

No mortality or major complications such as mediastinitis, sternal osteomyelitis, respiratory or renal failure were seen in either group. The incidence of the following minor complications in group A was as follows: atrial fibrillation: 19.6%, myocardial infarction: 9.8%, wound infection: 7.8 %, pericardial effusion: 7.8%, pleural effusion: 35.3 %, and readmission: 25.5%.

In group B, these incidences were as follows: atrial fibrillation: 10.2%, myocardial infarction: 2%, wound infection: 6.1 %, pericardial effusion: 8.2%, pleural effusion: 24.5% and readmission: 18.4% (Fig 2).

Adequate 2D and Doppler recordings were obtained from all patients. Global RVEF and RVMPI variables were measured at the pre-operative period, and one month and four months after surgery.

Pre-operative RVMPI was more in females than in males in both groups (P=0.07). rRVEF (difference between pre-operative RVEF and 4-month post-operative RVEF) was higher in patients who were more than 50 years old (P=0.047). In group B, pre-operative RVMPI and RVEF were more in smokers than in non-smokers (P=0.055). This difference was not seen in group A. There was no meaningful statistical difference in evaluated items between

Complications		Group A				Group B			
		Mean RVEF (0)	*Mean LVEF (0)*	*Mean RVMPI (0)*	*Mean LVMPI (0)*	*Mean RVEF (0)*	*Mean LVEF (0)*	*Mean RVMPI (0)*	*Mean RVMPI (0)*
AF	*Yes*	0.41	0.37	0.50	0.62	0.44	0.50	0.45	0.52
	No	0.42	0.38	0.46	0.57	0.45	0.48	0.43	0.55
MI	*Yes*	0.42	0.36	0.47	0.53	0.35	0.45	0.56	0.58
	No	0.42	0.38	0.46	0.58	0.45	0.49	0.43	0.54
Pericardial effusion	*Yes*	0.40	0.35	0.52	0.61	0.43	0.48	0.41	0.59
	No	0.42	0.38	0.46	0.57	0.45	0.49	0.43	0.54
Pleural effusion	*Yes*	0.41	0.38	0.46	0.58	0.45	0.49	0.42	0.54
	No	0.42	0.38	0.46	0.58	0.44	0.48	0.44	0.55
Infection	*Yes*	0.45	0.38	0.48	0.60	0.38	0.46	0.45	0.50
	No	0.41	0.38	0.46	0.57	0.45	0.49	0.43	0.55
Readmission	*Yes*	0.43	0.37	0.48	0.59	0.42	0.48	0.48	0.54
	No	0.41	0.38	0.46	0.57	0.45	0.49	0.42	0.55

Table.1. Correlation between RVMPI, LVMPI and postoperative complications.

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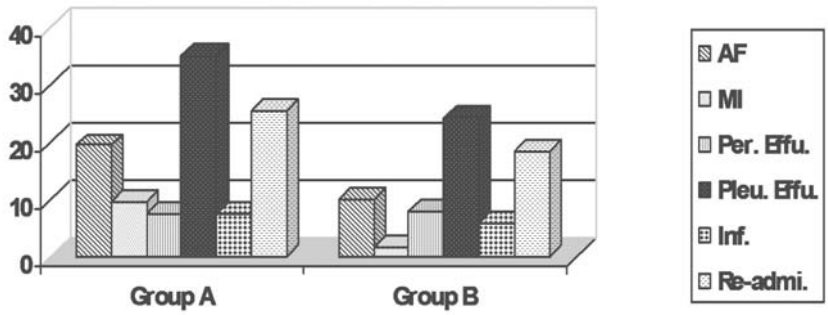


Fig. 2. Complications.

hypertensive and non-hypertensive patients. In group A, RVMPI was higher in non-diabetics than diabetics in all phases of the study (P=0.001). RVEDV was more in diabetics in all phases (P=0.022). Pre-operative right atrial volume was higher in non-diabetic patients in both groups (P=0.041).

No meaningful statistical correlation between RVEF, RVMPI, PA pressure, RVEDV, RV volume and the incidence of post-operative AF rhythm was observed in both groups.

There was no correlation between RVEF, RVMPI, RVEDV and the incidence of post-operative myocardial infarction in both groups. But in group A, pre-operative PA pressure and RV volume were higher in patients with post-operative MI (P=0.9), (P=0.024). In group B, the number of patients who had myocardial infarction was very low and could not lead to any conclusion.

In group A, in patients who had pericardial effusion, RVEF, RVMPI, PA pressure, RVEDV and RA volume did not show any significant differences in all phases. But in group B, RA volume was more in patients with pericardial effusion in all phases (P=0.000) although other studied factors did not show any differences between the two subcategories. On the other hand, four-month post-operative RVEF was significantly less in patients who had pericardial effusion (P=0.005).

In group B, there was no meaningful statistical correlation between RVMPI, RVEF, PA pressure, RVEDV, RA volume and the incidence of post-operative pleural effusion in all phases. In group A, no correlation was seen between pre-operative RVEF, RVEDV, RA volume, PA pressure and post-operative pleural effusion. However, four-month post-operative RVMPI and PA pressure were significantly higher in patients with post-operative pleural effusion, (P=0.074), (P=0.065).

In group A, no meaningful statistical correlation was seen between RVMPI, RVEF, RVEDV, PA pressure and the incidence of post-operative wound and sternal infection but pre-operative RA volume was more in patients who had post-operative infection (P=0.035).

In group B, pre-operative PA pressure was more in patients with post-operative infection (P=0.043), but other factors did not show a meaningful correlation.

There was no correlation between RVEF, RVMPI and dose of inotrope intake in both groups. In group A, the patients who received a high dose of inotrope, had more RVEF improvement (rRVEF) (P=0.064). This change was not seen in group B. However, in group B, PA pressure was more in patients who received a higher dose of inotrope in all phases (P=0.022).

No meaningful statistical correlation was found between studied factors and length of ICU stay in group A. One exception was seen; the four-month post-operative RVMPI was more in patients with longer ICU stay

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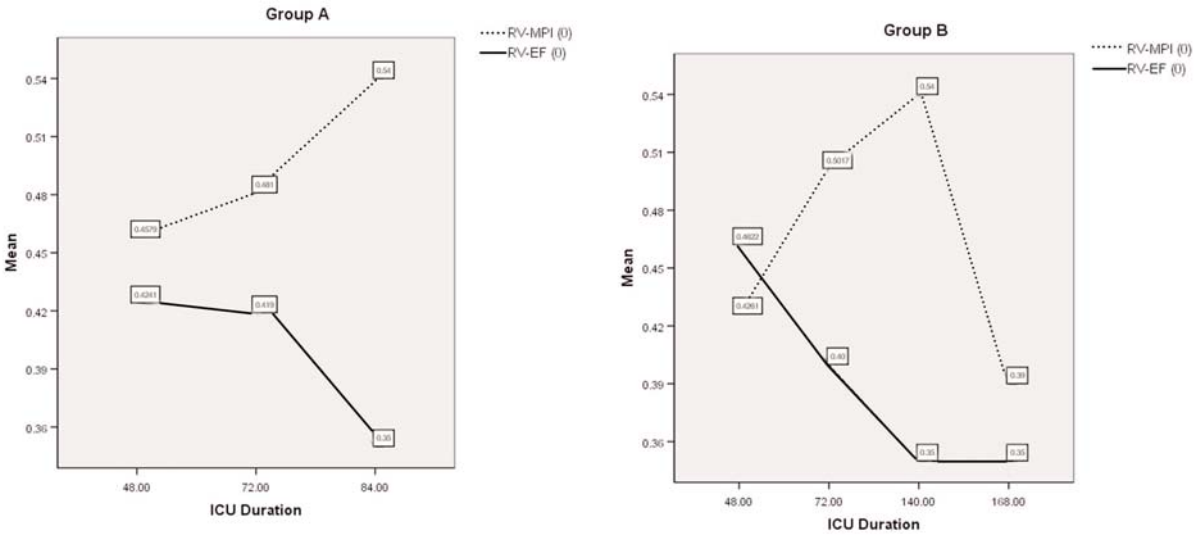


Fig. 3. ICU duration.

(P=0.035). In group B, RVMPI was higher in patients with longer ICU stay in all phases (P=0.000). Also, pre-operative RVEF was less in these patients (P=0.001) (Fig 3).

In group A, no correlation was seen between variables and ventilation time. In group B, patients with longer ventilation time had more pre-operative RVMPI (P=0.033) (Fig. 4), more pre-operative RVEDV (P=0.000) and less pre-operative RVEF (P=0.015).

There was no correlation between RVEF, RVMPI, PA pressure, RVEDV and readmission rate in both groups. It was interesting that the four-month post-operative RVEDV, RA volume was more in patients who had readmission (P=0.001), (P=0.021) and also more in these patients at four months after the surgery (P=0.012).

Discussion

CABG is one of the most common treatments of coronary artery diseases. Considering the extent to which this procedure is performed and also the higher risk patients undergoing it have,

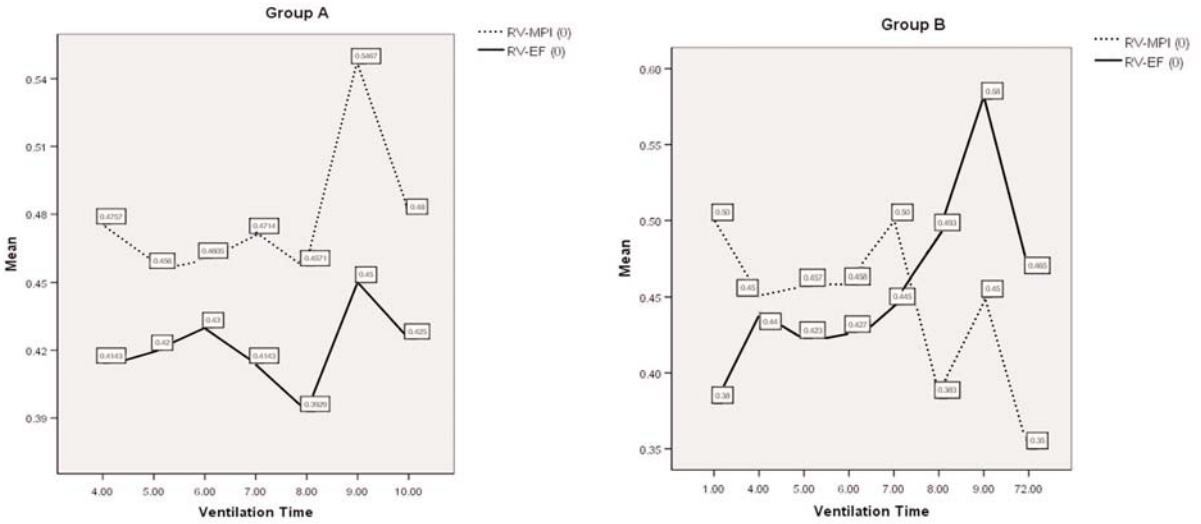


Fig. 4. Ventilation time.

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we need to recognize factors that affect its prognosis. A most important factor is the global LV systolic function. In our previous study which has not been published, we investigated the impact of LVMPI on the prognosis of such patients and compared it with that of LVEF (Table 1). The right ventricle and its function are usually ignored in heart surgeries although they are effective in patients' prognosis. This study aims to find the effects of right ventricle function on post-op complications by measuring global RVEF and RVMPI.

Complex anatomy and crescentic shape of the right ventricle makes it hard to evaluate its function. In addition to global RVEF, we can use RVMPI to evaluate systolic and diastolic function of the right ventricle. This parameter is measured easily but has some clinical limits in practice, which are: 1. pseudonormalization in patients with severe RV dysfunction, 2. heart block and 3. arrythmia. We excluded patients with the above-mentioned conditions. Also, RVMPI seems to be preload dependent, but we tried to keep the patients homogeneous.

There has been a lot of research on RVMPI, including the study by Murphy et al in patients undergoing the Senning procedure which showed that patients with preserved right ventricular function had values for the RVMPI lower than 0.47 [9]. Sajam Narayanan and A Ajith et al. showed that early performance of Doppler-derived RVMPI is useful in risk stratification of patients with acute ST elevation MI. A higher value of this index is associated with adverse in-hospital outcomes [10].

In another study, Kurtulu Ozdemir et al showed that RVMPI > 0.7 may define RVMPI concomitant with acute inferior MI [5]. Also, RVMPI was seen impaired in patients with uremia [11]. There is not much finding regarding the effect of RVMPI on prognosis of CABG patients. We aimed to study the relationship between right heart volumes, pulmonary artery pressure, RVEF, RVMPI and CABG post-op complications.

Post-op AF rhythm did not have a significant relationship with RVEF, RVMPI, pulmonary artery pressure and right heart volumes. Furthermore, AF rhythm did not have a negative effect on the recovery of the right ventricle function after surgery. Meanwhile, AF rhythm delayed recovery of LV function in group A in our previous study. The incidence of post-op MI was not correlated with RVEF, RVMPI and RVEDV in both groups. However, patients who had MI in group A had higher pulmonary artery pressure and higher right ventricular volume before surgery compared with those who did not have MI. Post-op MI did not affect recovery of RVEF and RVMPI, but in our previous study, post-op MI delayed the recovery of LVEF and LVMPI.

There is no significant relationship between the studied parameters and ICU stay in group A, but in group B patients with longer ICU stay had higher RVMPI and lower RVEF. In our previous study, we found pre-op LVEF was effective in the length of ICU stay in group A.

We did not find a significant relationship between the studied parameters and duration of mechanical ventilation in group A. However, in group B patients who needed longer mechanical ventilation, higher pre-operative RVMPI and RVEDV and lower pre-op RVEF was observed.

In conclusion, it seems that studying RV function and pulmonary artery pressure can mainly predict the length of ICU stay and the need for mechanical ventilation only in group B, but it does not affect minor post-op complications.

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