Original Article

Non Invasive Assessment of Myocardial Perfusion after First Myocardial Infarction with Transthoracic Echocardiography

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Abstract

Background: *Standard methods for the measurement of myocardial perfusion are invasive and require cardiac catheterization or the use of radioisotope dyes. The coronary sinus blood flow (CSBF) is an appropriate criterion for the efficacy of myocardial perfusion. This study sought to measure CSBF via transthoracic echocardiography (TTE) in patients with acute myocardial infarction (AMI) and to assess its relation with left ventricular ejection fraction (LVEF), wall motion scoring index (WMSI), and in-hospital mortality.*

Methods: *This case-control study evaluated 20 patients (pts) with anterior AMI and 20 healthy individuals as controls over a 6-month period (in 2005) in Madani Heart Center in Tabriz (Iran). All the patients received the same drugs for AMI treatment (e.g. fibrinolytic). CSBF and WMSI, having been obtained via TTE, were compared between the two groups.*

Results: *Baseline variables were similar between the two groups (P>0.05). CSBF in the AMI group was 287.8±128 ml/min and in the control group was 415±127 ml/min (P=0.001). There was a significant correlation between CSBF and LVEF (r=0.52, P=0.01), between CSBF and WMSI (r=-0.77, P=0.0001), and between CSBF and in-hospital mortality (r=0.58, P=0.03).*

Conclusion: *Our study demonstrated a good correlation between CSBF measured with 2D-doppler TTE and LVEF, WMSI, and in-hospital mortality.*

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Introduction

The coronary sinus blood flow (CSBF) is often utilized as a measure of cardiac perfusion. However, the standard techniques for the measurement of cardiac perfusion are invasive and require cardiac catheterization (intravascular Doppler flow wire, thermodilution catheter, or digital coronary angiography) or the use of radioisotope dyes (argon technique or xenon scintigraphy).[1] Pervious studies have described the use of transesophageal echocardiography

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(TEE) in the measurement of CSBF and coronary flow reserve and demonstrated the feasibility and reproducibility of TEE in measuring CSBF. In contrast to TEE, transthoracic echocardiography (TTE) with Doppler flow measurement provides a non-invasive means of measuring CSBF. Daniel Wing Chong NG et al.,[1] having applied this non-invasive method, succeeded in demonstrating a statistically significant increase in the coronary artery flow after revascularization procedures, a finding previously established by invasive studies.

The aim of this study was to measure CSBF via TTE in patients with acute myocardial infarction (AMI) and to assess its relation with left ventricular ejection fraction (LVEF), wall motion scoring index (WMSI), and in-hospital mortality.

Methods

The study was approved by the Ethics Committee of our institution, and written informed consent was obtained from all the patients. In this case control study, 20 patients with anterior MI and 20 healthy individuals as controls were studied over a 6-month period (in 2005) in Madani Heart Center in Tabriz (Iran). Acute anterior myocardial infarction was defined as the presence of typical chest pain lasting for more than 30 minutes, ST-segment elevation of more than 0.1 mV in the adjacent V_{1-4} leads, and a serum creatine kinase concentration that was more than twice the upper limit of the normal range. Standard 12-lead and right precordial electrocardiograms were obtained immediately after admission. The twenty healthy individuals were selected from the hospital staff and the patients' adult relatives with no history of cardiovascular diseases. All the patients received the same drugs for AMI treatment (e.g. streptokinase). We did not receive funds for the study from any other party other than our own institution.

CSBF and WMSI data were obtained via TTE 48 hours after admission and compared between the two groups. Echocardiographic studies were performed by a single expert cardiologist. A 2.5-MHZ transducer of commercially available echocardiography equipment (VIVID7, GE, USA) was used. The coronary sinus diameter was measured in the posterior angulated four-chamber view, and its flow was obtained in the right ventricular (RV) inflow view with optimized zooming and the placement of the pulse wave sample volume (PWSV) in its orifice to record the blood flow. CSBF was identified through systolic and diastolic signals with very little respiratory variation. The coronary sinus velocity time integral (CSVTI) was measured by outlining the flow velocity signal and using a computer algorithm in the ultrasound machine. The coronary sinus was then imaged in the apical four-chamber view of the coronary sinus, with posterior tilting of the transducer.

The diameters of the coronary sinus were taken at five equally spaced segments in the cardiac cycle over three cardiac cycles before they were averaged and used as the major diameter of the coronary sinus. Assuming that the cross section of the coronary sinus is an ellipse and that the major diameter is double the length of the minor diameter, the cross–sectional area of the CS was calculated as: [0.39 × (the major diameter)^2]. CSBF was then calculated as: [(CSVTI) × (cross-sectional area of the CS) × (heart rate)].

Collected variables between the two groups were analyzed using SPSS vs.13.0 (SPSS Inc. Chicago, IL) statistical package. Continuous parameters are expressed as mean and standard deviation. Comparisons between the continuous variables recorded from the control and AMI groups were made by an independent samples t-test. Categorical variables between the two groups were analyzed with a Chi-square or Fisher's exact test as appropriate. Statistical significance was accepted when $P \leq 0.05$.

Results

Baseline variables (age, sex, history of diabetes mellitus, hypertension, hyperlipidemia, smoking, and body mass index) were similar between the two study groups. Also, heart rate and coronary sinus diameter were similar between the two groups (Table 1). The coronary sinus was visualized in all the 20 AMI patients and 20 control participants with adequate samples of coronary sinus flow velocity. All the patients were in sinus rhythm. Two patients in the AMI group died during hospital stay, but there was no mortality in the control group.

CSBF in the AMI group was 287.8±128 ml/min, while in the control group it was 415±127 ml/min (P=0.001). Figure 1 shows the correlations between CSBF and LVEF (r=0.52, P=0.01), between CSBF and WMSI (r=-0.77, P=0.0001), and between CSBF and in-hospital mortality (n=2), (r=0.58, P=0.03).

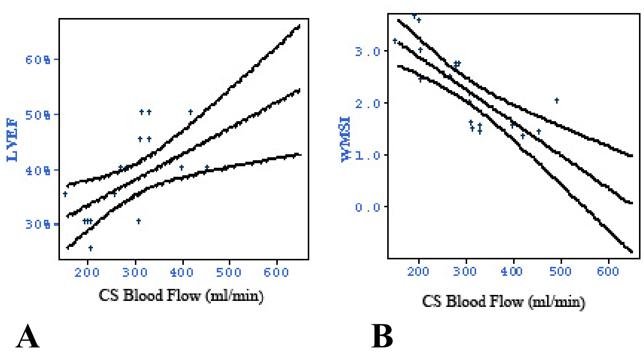

Figure 1. Linear regression between coronary sinus (CS) blood flow and left ventricular ejection fraction (LVEF; plot A), and wall motion scoring index (WMSI; plot B) in patients with acute myocardial infarction

Table 1. Baseline characteristics*

Variable	Acute MI group (n=20)	Control Group (n=20)	P value
Age (yr)	53.8±12.4	47.9±12.3	0.0136
Sex (M/F)	15/5	14/6	1.000
Height (cm)	168±10	167±9	0.784
Weight (kg)	77±15	72±12	0.272
BMI	27.1±3.9	25.8±3.6	0.284
LVEF	0.39±7%	0.58±4%	0.0001
Smoking	8(40%)	4(20%)	0.271
Dyslipidemia	9(45%)	7(35%)	0.748
Hypertension	9(45%)	4(20%)	0.177
Diabetes Mellitus	3(15%)	2(10%)	1.000
Coronary sinus diameter (cm)	0.88±0.15	0.83±0.17	0.120
Heart rate (per minute)	80±10	73±12	0.100

*Values are shown as mean±SD

MI, Myocardial infarcation; BMI, Body mass index; LVEF, Left ventricular ejection fraction

Discussion

Several studies have demonstrated that AMI produces a remarkable decrease in CSBF. Be that as it may, an objective measurement of CSBF has traditionally required invasive studies.[1-3] Terekhov VN[4] assessed CSBF in 42 patients using a continuous thermodilution technique in the presence of thrombolytic treatment. The coronary venous flow was shown to have increased by 20% and more in 17 patients, more than 30% in 15, and more than 40% in 10 after treatment with streptokinase.

Inferior wall MI was associated with a significant increase in the blood flow rate in the coronary sinus as well as in other cardiac veins, while anterior MI was associated with a flow rate increase in the coronary sinus only. Bogatyrev IV[2] by continuous coronary sinus thermodilution showed that patients with anterior MI had a significantly less blood flow in the vena cordis magna than did those with posterolateral infarction. However, continuous coronary sinus thermodilution cannot be used for an indirect identification of the site of myocardial infarction.

Other techniques employed for the measurement of CSBF are CS myocardial clearance technique (Fick), positron emission tomography, MRI, radionuclide imaging, and recently TEE. It is noteworthy that all of these techniques are invasive or expensive.[5,6]

The koskenvuo JW study[7] demonstrated that the global myocardial blood flow and global flow reserve measurements via MRI and PET were comparable.

Bates et al.,[8] having used a digital radiographic technique during cardiac catheterization to measure the coronary flow before and after revascularization, demonstrate an elevated homodynamic state, which implied an increased coronary blood flow.

Toyota S and Amaki V[9] were able to measure the CS flow velocity using pulse-Doppler TEE during coronary artery bypass graft (CABG) surgery. The peak velocity and VTI of CSBF in the post–cardiopulmonary bypass period increased significantly compared with those in the pre-cardiopulmonary bypass period. The results of this preliminary study showed the feasibility of a clinical evaluation of CABG intraoperatively. Siostrzonek P[10] showed a strong association between CSBF measured with TEE and coronary sinus catheterism.

Using xenon-133 scintigraphy, Goldman et al.[11] measured the blood flow before and after bypass surgery involving the left anterior descending vessels and found that the blood flow normalized after CABG, with the blood flow at rest in the bypassed arteries being very similar to that measured in normal coronary vessels. Chatterjec K et al.[12] showed that, in patients with aortocoronary bypass surgery, CSBF was higher after surgery than it was before surgery. More recently, Crone-Munzebrocke et al.[13] conducted thallium-201 scintigraphic studies of myocardial perfusion scanning before and after CABG. They found that thallium-201 uptake and washout in thallium-201 scintigraphy improved after CABG and that CSBF during pacing improved after CABG. By using the non-invasive method of measuring CSBF via TTE, Daniel Wing Chong NG et al.[1] were able to show a statistically significant increase in the coronary artery flow after revascularization procedures, a finding previously established by invasive studies.

There is no information in the existing medical literature on the use of TTE for the measurement of CSBF in AMI patients. The present study, having utilized this non-invasive method, found a statistically significant decrease in the coronary artery flow after AMI, a finding that has thus far been observed only through invasive studies. Our data showed a decrease in CSBF in the AMI group. In general, the decrease in CSBF was not related to the initial flow and was within the range of 100 to 200 ml/min.

Moreover, CSBF had a good correlation with LVEF, WMSI, and in-hospital mortality.

The limitation of this study was the inability to compare the measured data with those of an invasive technique. Nonetheless, our results correlated well with those invasive studies by demonstrating a decrease in CSBF after AMI.

Conclusion

The findings of the present study revealed that TTE can be used to measure CSBF in AMI patients. This clinically important finding, in accordance with previous invasive studies, suggests that TTE can be applied as a non-invasive modality to monitor changes in CSBF and to determine coronary perfusion in MI patients.

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