

Measurement of coronary sinus blood flow after first anterior myocardial infarction with transthoracic echocardiography and its correlation with wall motion scoring index

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ABSTRACT

Objectives: To measure the coronary sinus blood flow (CSBF) and coronary sinus velocity time integral (CSVTI) via transthoracic echocardiography (TTE) in patients with acute myocardial infarction (AMI) in association with the left ventricular ejection fraction (LVEF), and wall motion scoring index (WMSI).

Methods: In this case-control study, 20 patients with anterior AMI and 20 healthy individuals as the control group, were studied in 6 months period from March to September 2005 in Madani Heart Center, Tabriz, Iran. All patients received the same treatment for AMI (such as fibrinolytic). The CSBF, CSVTI, WMSI, and tissue Doppler imaging (TDI) data were obtained via TTE and compared between the 2 groups.

Results: Baseline variables were similar between the 2 groups ($p>0.05$). The CSBF in AMI group was 287.8 ± 128 ml/min and in the control group was 415 ± 127 ml/min ($p=0.001$). Also, CSVTI was significantly lower in AMI group than control group (11.16 ± 2.85 and 17.56 ± 2.72 mm, $p=0.003$). There was a significant correlation between CSBF and LVEF ($r=0.52$, $p=0.01$), WMSI ($r=-0.77$, $p=0.0001$) and CSBF and in-hospital mortality ($r=0.58$, $p=0.03$), also between CSVTI and LVEF ($r=0.85$, $p=0.0001$), WMSI ($r=-0.57$, $p=0.0009$) and in-hospital mortality rate ($r=0.69$, $p=0.02$). The CSBF and CSVTI had a good correlation with TDI findings: peak early diastolic velocity in the myocardium and peak systolic velocity in the myocardium).

Conclusion: Our study demonstrated a good correlation between measured CSBF and CSVTI by 2D-Doppler TTE and LVEF, WMSI, in-hospital mortality and TDI findings.

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Coronary sinus blood flow (CSBF) is often used as a measure of cardiac perfusion. However, the standard techniques for 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 Previous studies described the use of transesophageal echocardiography (TEE) in the measurement of CSBF and coronary flow reserve and demonstrated the feasibility and reproducibility of TEE in measuring coronary sinus flow. In contrast to TEE, transthoracic echocardiography (TTE) with Doppler flow measurement provides a non-invasive means of measuring CSBF. By using this non-invasive method, NG et al¹ showed a statistically significant increase in the coronary artery flow after revascularization procedures, a finding established by invasive studies. The aim of this study was to measure CSBF and coronary sinus velocity time integral (CSVTI) via TTE in patients with acute myocardial infarction (AMI) and its relation with the left ventricular ejection fraction (LVEF), wall motion scoring index (WMSI), and in-hospital mortality.

Methods. After approval in our institution ethics committee, and obtaining written informed consent; 40 adult patients enrolled into the study. In this case control study, 20 patients with anterior MI and 20 healthy individuals as controls were studied in 6 months period from March to September 2005 in Madani Heart Center, Tabriz, Iran. Twenty healthy individuals selected from hospital staff and patient's adult relatives who had no history of cardiovascular diseases. All patients received same drugs for AMI treatment (such as streptokinase). The CSBF,

CSVTI, WMSI, and tissue Doppler imaging (TDI) data were obtained via TTE and compared between the 2 groups. The echocardiographic study was performed by a single expert cardiologist. A 2.5 MHz transducer of commercially available echocardiography equipment (VIVID7, GE, USA) was used. The coronary sinus (CS) diameter measured in the posterior angulated 4-chamber view, and its flow was obtained in the right ventricular inflow view with optimize zooming and placing of pulse wave sample volume in its orifice to record the blood flow. The CSBF was identified by systolic and diastolic signals with a very little respiratory variation (**Figures 1 & 2**). The CSVTI was measured by outlining the flow velocity signal using a computer algorithm in the ultrasound machine. The CS was then imaged in the apical 4-chamber view of the CS, with posterior tilting of the transducer (**Figure 2**). Diameters of the coronary sinus took at 5 equally spaced segments in the cardiac cycle, over 3 cardiac cycles, the average of 5 measurements used as the major diameter of the CS. Assuming the cross-section of the CS is an ellipse and the major diameter is double the length of the minor diameter, the cross-sectional area of the CS was calculated as: $[0.39 \times (\text{the major diameter})^2]$. The CSBF was then calculated as: $[(\text{CSVTI}) \times (\text{cross-sectional area of the CS}) \times (\text{heart rate})]$. Patients with anterior MI who admitted 48 hours ago and received streptokinase were included in the study. Patients who had post-MI arrhythmia or post-MI mitral regurgitation and who had cardiogenic shock or creatinine more than 2mg/dl, or who underwent early percutaneous transluminal coronary angioplasty and patients who had poor-view echocardiography

Collected variables between the 2 groups were analyzed by SPSS version 13.0 (SPSS Inc. Chicago, IL). Continuous parameters were expressed as mean \pm

standard deviation. Comparisons between the continuous variables recorded from the control and AMI groups were carried out using independent samples t-test. Categorical variables between the 2 groups were analyzed by Chi-square or Fisher's exact test as appropriate. Statistical significance was accepted when $p \leq 0.05$.

Results. Baseline variables (age, gender, history of diabetes mellitus, hypertension, hyperlipidemia, smoking, and body mass index) were similar between the 2 study groups. Also, heart rate and CS diameter were similar in the 2 groups (**Table 1**). The CS was visualized in all 20 AMI patients and 20 control participants with adequate samples of CS flow velocity. All patients were in sinus rhythm. Two patients in AMI group died during hospital stay, but there was no mortality in the control group. The VTI in AMI group was significantly lower than control group (11.16 ± 2.85 cm versus 17.56 ± 2.72 cm; $p=0.003$). The CSBF in AMI group was 287.8 ± 128 ml/min while in control group was 415 ± 127 ml/min ($p=0.001$; **Table 2**). **Figure 3** shows correlations between CSBF and LVEF ($r=0.52$, $p=0.01$), WMSI ($r=-0.77$, $p=0.0001$) and in-hospital mortality ($r=0.58$, $p=0.03$). Also, there was relatively high correlation between CSVTI and LVEF ($r=0.85$, $p=0.0001$), WMSI ($r=-0.57$, $p=0.009$) and in-hospital mortality rate ($r=0.69$, $p=0.02$; **Figure 4**). The CSBF and CSVTI had positive correlation with the TDI findings; Em (peak early diastolic velocity in the myocardium) and Sm (peak systolic velocity in the myocardium). Linear regression analysis (**Figure 5**) showed moderate but statistically significant correlation between CSBF and Em ($r=0.47$; $p=0.037$), and with Sm ($r=0.47$; $p=0.038$). Also, there was a similar correlation between CSVTI and Em ($r=0.53$; $p=0.02$), and with Sm ($r=0.46$; $p=0.042$).

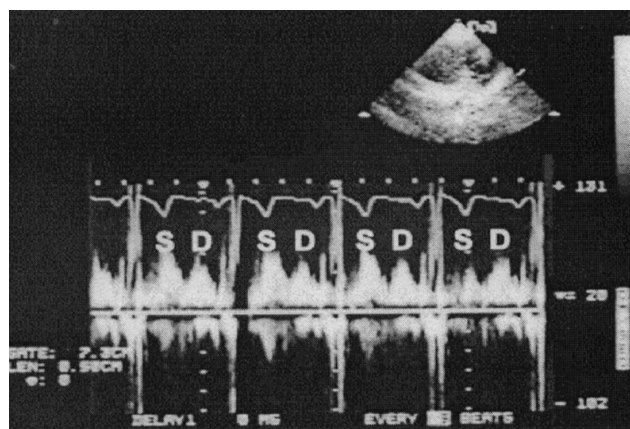


Figure 1 - Biphasic Doppler flow pattern recording in a coronary sinus characterized by systolic and diastolic anterograde flows. S - systolic flow, D - diastolic flow

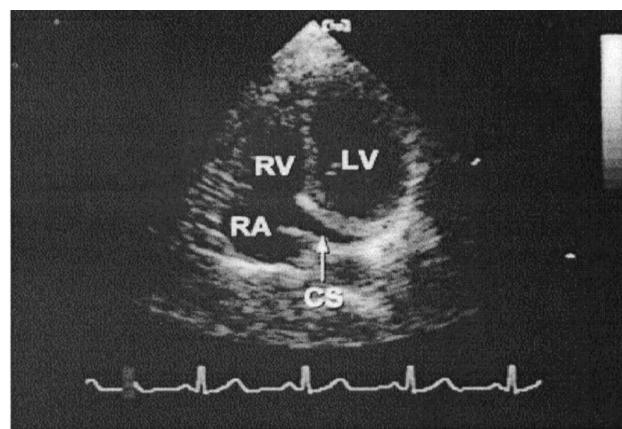


Figure 2 - Modified apical 4-chamber view demonstrating clear visualization of the coronary sinus (CS) with posterior tilting of the transducer. LV - left ventricle, RA - right atrium, RV - right ventricle

Discussion. Several studies have demonstrated that AMI produces remarkable decrease in CSBF. However, an objective measurement of CSBF has traditionally required invasive studies.¹⁻³ Terekhov et al⁴ assessed CSBF in 42 patients using continuous thermodilution technique in the presence of thrombolytic treatment. The coronary venous flow was shown to increase by >20% in 17 patients, >30% in 15 patients, and >40% in 10 patients after treatment with streptokinase. Inferior wall MI was associated with a significant increase of blood flow rate in the CS as well as other cardiac veins, while anterior MI was associated with flow rate increase in the CS only. Continuous CS thermodilution in patients with anterior MI shows a significantly less blood flow in the vena cordis magna than those with posterolateral infarction. However, it cannot be used for indirect identification of the site

of MI. Other techniques used for measurement of CSBF were CS myocardial clearance technique (Fick), positron emission tomography, MRI, radionuclide imaging and TEE; these techniques are invasive and expensive.^{5,6} Koskenvuo et al⁷ demonstrated that global myocardial blood flow and global flow reserve measurements by MRI and PET are comparable. Bates et al⁸ used a digital radiographic technique during cardiac catheterization to measure the coronary flow before and after revascularization procedures to demonstrate an elevated hemodynamic state, implying an increased coronary blood flow. Toyota and Amaki⁹ measured the CS flow velocity by pulse-Doppler TEE during coronary artery bypass graft (CABG) surgery. The peak velocity and VTI of CS blood flow in the post-CPB period increased significantly compared with the pre-CPB period by CABG. The results of this preliminary

Table 1 - Baseline characteristics in patients in the 2 study groups.

Variables	Acute myocardial infarction group (n=20)	Control group (n=20)
Age (year) mean±SD	53.8 ± 12.4	47.9 ± 12.3
Gender (male/female)	15/5	14/6
Height (cm) mean±SD	168 ± 10	167 ± 9.0
Weight (kg) mean±SD	77 ± 15	72 ± 12
BMI (mean±SD)	27.1 ± 3.9	25.8 ± 3.6
LVEF (mean±SD)	0.39 ± 7.0	0.58 ± 4.0
Smoking (%)	8 (40)	4 (20)
Deslipidemia (%)	9 (45)	7 (35)
Hypertension (%)	9 (45)	4 (20)
Diabetes mellitus (%)	3 (15)	2 (10)
Coronary sinus diameter (cm) mean±SD	0.88 ± 0.15	0.83 ± 0.17
Heart rate (beat/min) mean±SD	80 ± 10	73 ± 12

LVEF - left ventricular ejection fraction
BMI - body mass index

Table 2 - Comparison of coronary sinus parameters between the 2 groups.

Variables	Acute myocardial infarction Group (n=20) mean±SD	Control Group (n=20) mean±SD	P value
CSBF (ml/min)	287.8 ± 128	415 ± 127	0.001
CSVTI (cm)	11.16 ± 2.85	17.56 ± 2.72	0.003

CSBF - coronary sinus blood flow
CSVTI - coronary sinus velocity time integral

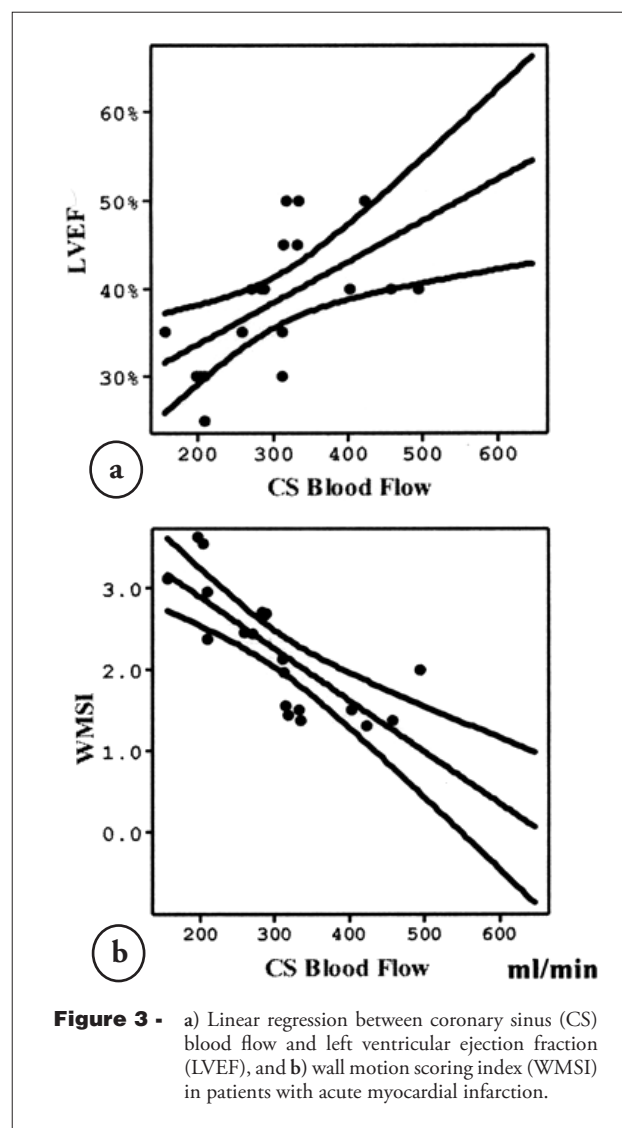
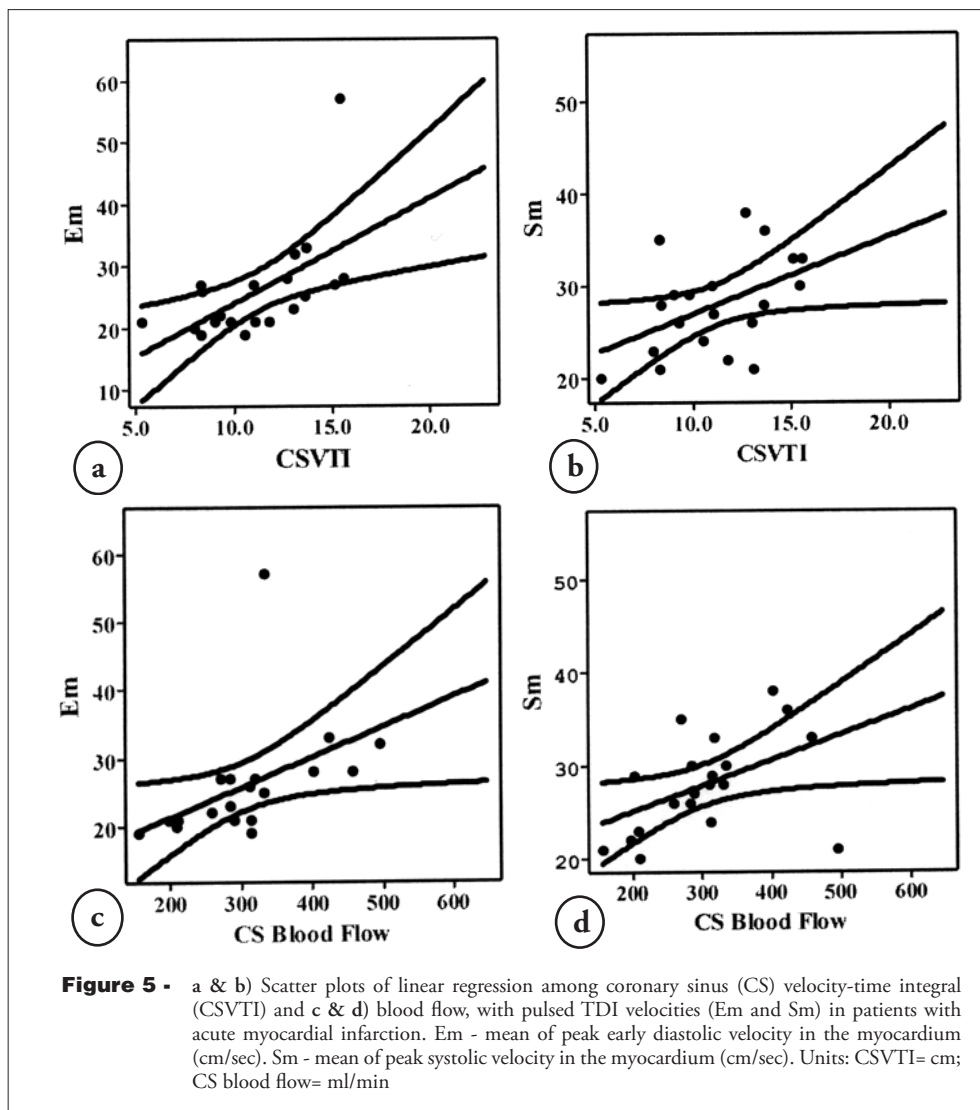
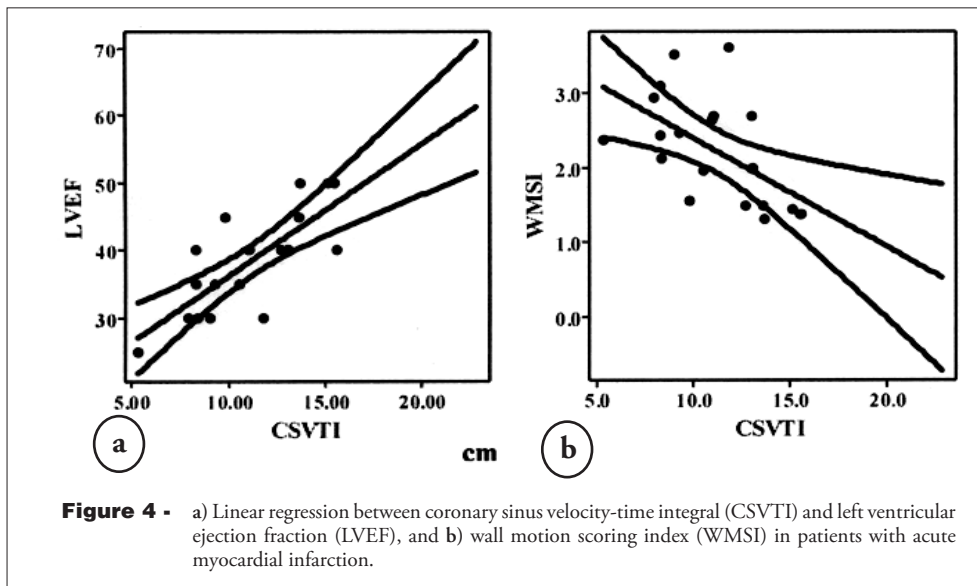


Figure 3 - a) Linear regression between coronary sinus (CS) blood flow and left ventricular ejection fraction (LVEF), and b) wall motion scoring index (WMSI) in patients with acute myocardial infarction.



study show the feasibility of clinical evaluation of CABG intraoperatively. Siostrzonek et al¹⁰ showed the strong association between CSBF measured by TEE and coronary sinus catheterism. Using xenon -133 scintigraphy, Goldman et al¹¹ measured the blood flow before and after bypass surgery involving the left anterior descending vessels and found that the blood flow was normalized after CABG, with blood flow at rest in the bypassed arteries being very similar to that measured in normal coronary vessels. Chatterjec et al¹² showed that, in patients with aortocoronary bypass surgery, CSBF was higher after than before surgery. More recently, Crone-Munzebrock et al¹³ 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 non-invasive method of measuring CSBF by TTE, only the study of Ng et al¹ showed a statistically significant increase in coronary artery flow after revascularization procedures, a finding that previously established by invasive studies. Using non-invasive method of measuring CSBF by TTE, we found a statistically significant decrease in CAF after AMI, a finding that previously observed by invasive studies. We observed a decrease in CSBF and CSVTI in AMI group. In general, the decrease in CSBF was not related to the initial flow and considering the range of 100-200 ml/min. Also, we observed that CSBF and CSVTI had a good correlation with LVEF, WMSI, and in-hospital mortality. The demonstration of the correlation between CSBF and CSVTI with TDI findings (Em and Sm) was important and it is a new finding in the study. The limitation of this study is the inability to compare the measured data with those using invasive technique, but our results were well correlated with invasive studies by demonstrating the decrease in CSBF and CSVTI after AMI.

In conclusion, the TTE can use to measure CSBF in patients with AMI. This clinically important finding, in accordance with previous invasive studies, suggests that TTE can use as a non-invasive modality to monitor changes in CSBF and to determine coronary perfusion in patients with MI.

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