European Review for Medical and Pharmacological Sciences 2022; 26: 3893-3902

Association of CABG SYNTAX score with long term clinical outcomes in patients with acute myocardial infarction undergoing SVG PCI

Ö.Ç. KARAASLAN[1], O. MADEN[1], Y. KANAL[2], İ. YAKUT[1], N.M. YAMAN[1], H.C. KÖNTE[3], M.T. SELÇUK[1], H. SELÇUK[1]

[1]Department of Cardiology, Ankara City Hospital, Ankara, Turkey
[2]Department of Cardiology, Başakşehir Çam and Sakura City Hospital, Istanbul, Turkey
[3]Department of Cardiology, Muş State Hospital, Muş, Turkey

Abstract. – OBJECTIVE: The CABG SYNTAX score (CSS) has been recommended as an objective and quantitative evaluation tool for coronary anatomic complexity after CABG. We aimed at evaluating the long-term prognostic value of the CSS and its relationship with the composite criteria of all-cause death, cerebrovascular accident (CVA) and/or non-fatal myocardial infarction (MI) in patients who underwent percutaneous coronary intervention (PCI) of saphenous vein graft (SVG).

PATIENTS AND METHODS: We retrospectively evaluated 232 patients who were admitted with MI and underwent PCI of SVGs, between 2012 and 2018. The study population was divided into two groups according to the results of the median pre-PCI CSS.

RESULTS: The composite criteria of all-cause death/CVA/non-fatal MI were observed in 107 patients (46.1%). The incidence of the primary endpoint was significantly higher among the patients with a high pre-PCI CSS ($p < .001$). Multivariable Cox regression analyses demonstrated that both pre-PCI CSS (HR = 1.678, 95% CI = 1.082-2.602, $p = .021$) and post-PCI CSS (HR = 1.663, 95% CI = 1.066-2.596, $p = .025$) were significantly associated with the primary endpoint. The Kaplan–Meier cumulative curves divided by the median of the pre-PCI CSS demonstrated that, compared with the low pre-PCI CSS group, the high-score group was associated at five years with higher composite criteria of all-cause death/CVA/non-fatal MI (low, 40.3%; high, 57.8%; $p = .015$).

CONCLUSIONS: Pre-PCI CSS is a significant prognostic factor for the long-term clinical outcomes in patients with previous CABG who underwent PCI of SVG.

Key Words:
Percutaneous coronary intervention, Saphenous vein graft, The CABG SYNTAX score.

Introduction

Coronary artery bypass graft (CABG) surgery is the preferred revascularisation method for patients with left main coronary artery disease or three-vessel disease[1]. Long-term outcomes after CABG are commonly related to the patency of the vessels grafted to the coronary arteries[2]. Saphenous vein graft (SVG) remains widely used in patients undergoing CABG due to its easy accessibility and the need for multiple grafts[3]. However, difficulties in maintaining SVG patency and interventional complications regarding secondary revascularisation options still affect long-term clinical outcome[4].

The SYNTAX score is a prognostic tool that assesses the procedural risk of patients with complex coronary artery disease considered for revascularisation[5]. The baseline SYNTAX score calculated before CABG has been reported to be not associated with short and long-term prognosis after CABG[6,7]. Therefore, the CABG SYNTAX score (CSS) has been recommended as an objective and quantitative evaluation tool for coronary anatomic complexity after CABG[8]. A high CSS is associated with major adverse cardiac events at 5- and 10-year follow-ups after CABG[8,9].

The effect of percutaneous revascularisation on long term clinical outcomes in CABG patients is controversial because of paucity of evidence[10]. In particular, it is unclear whether the burden of atherosclerosis and residual ischemia load as assessed by the CSS is associated with clinical outcomes in patients who underwent SVG intervention which was well known to be associated with adverse procedural and postprocedural characteristics[11].

Therefore, we aimed to evaluate the long-term prognostic value of the CSS and its relationship with the composite criteria of all-cause death, cerebrovascular accident (CVA) and/or non-fatal myocardial infarction in patients admitted with acute myocardial infarction (AMI) who underwent PCI of SVG.

Corresponding Author: Özge Çakmak Karaaslan, MD; e-mail: ozgecakmak2323@gmail.com

Patients and Methods

Study Design and Population

Between January 2012 and January 2018, records of 291 consecutive patients with AMI and previous CABG who had stenosis or occlusion in one of their saphenous grafts deemed as culprit lesion of infarct based on electrocardiographic and angiographic characteristics and undergone PCI of that culprit SVG lesion at a tertiary hospital were retrospectively evaluated.

Patients with a known haematological disease (n = 2), a history of chronic inflammatory disease (n = 5) or autoimmune disease (n = 6), chronic kidney disease (CKD) and end-stage renal disease (ESRD) (n = 15), malignancy (n = 5), using oral anticoagulants (n = 7) or with missing clinical data (n = 12) were excluded from the study. Additionally, seven patients whose prior cardiac surgery was for valve disease or structural heart disease were also excluded. The patients whose culprit lesion was assessed to be on native coronary vessels or arterial grafts, or multiple vessels were also excluded. The final study population consisted of 232 patients with CABG who underwent PCI of SVG. The patients were divided into two groups according to the results of the median pre-PCI CSS. This retrospective observational study protocol was approved by the Local Ethics Committee of our hospital.

Angiographic Analyses, PCI Procedures and CABG SYNTAX Scores

Coronary angiography was performed with the standard Judkins technique via the femoral route (Siemens Axiom Artis Zee 2011; Siemens Healthcare, Erlangen, Germany). The exact timing of the coronary angiogram was left to the clinical judgement of the primary physician. Two experienced interventional cardiologists who were blinded to the clinical outcomes retrospectively reviewed the angiographic data of all the study patients and calculated the pre-PCI CSS by consensus using a previous report[8]. The pre-PCI CSS was analysed on the basis of the remaining coronary artery lesions before the PCI, and the post-PCI CSS was analysed on the basis of the remaining coronary artery lesions after the PCI[12]. In cases of inconsistency between the two reviewers, a third cardiologist's opinion was sought.

The patients undergoing PCI received 70-100 U/kg intravenous unfractionated heparin (Polifarma Pharmaceutical Industry, Turkey) before the procedure. The PCI procedures were performed using the transfemoral approach. The patients with AMI received a loading dose of aspirin (Bayer, Turkey) and, depending on the operator's discretion, a loading dose of clopidogrel (Sanofi Winthrop Industries, Paris, France) 600 mg, ticagrelor (AstraZeneca, Södertalje, Sweden) 180 mg or prasugrel (Accord Healthcare Limited, Middlesex, UK) 60 mg on admission or after the decision to proceed with PCI were taken. Procedural decisions, including device selection and adjunctive pharmacotherapy, such as glycoprotein IIb/IIIa inhibitors, were made at the operator's discretion. The infusion of tirofiban (DSM Pharmaceuticals Inc. Greenville, NC, USA) (25 mg/kg for 3 minutes, then 0.15 mg/kg/min for up to 24 hours) was administered if a bailout indication, such as high thrombus burden within the culprit vessel, acute vascular closure due to thrombosis or no reflows after stent implantation, occurred. The reperfusion status after the PCI of the SVG was evaluated based on the final angiographic images. Angiographic success was defined as < 25% diameter residual stenosis with Thrombolysis in Myocardial Infarction (TIMI) grade 3 flow[13]. No reflow was defined as the presence TIMI flow grade <3 in the infarct related saphenous graft, despite mechanical reopening without dissection, stenosis or vasospasm.

Follow-up and Endpoints

The follow-up time began at the first visit and ended with either the occurrence of the primary endpoint or the last visit. In the cases with rehospitalisation history after saphenous PCI the follow-up data were obtained from hospital records.

The primary endpoint was defined as a composite of all-cause death, CVA or non-fatal MI at follow-up time. The cause of death was ascertained from hospital records and death certificates obtained from the National Survival Registry. Furthermore, based on records deaths were sub-classified as cardiovascular and non-cardiovascular primary causes.

Cardiovascular death was defined as death due to MI, heart failure, malignant arrhythmia or sudden cardiac arrest because of unknown causes during hospitalisation and after discharge. A CVA was defined as an acute episode of neurologic dysfunction attributed to a central nervous system vascular cause confirmed by imaging modalities. A non-fatal MI diagnosis was based on the criteria defined by the current European Society of Cardiology guidelines[14]. An AMI was defined as the presence of cardiomyocyte necrosis detected by abnormal cardiac biomarkers in a clinical setting

Table I. Baseline characteristics of study groups according to pre-PCI CSS.

	All Group (n=232)	Low pre-PCI CSS (n = 118)	High pre-PCI CSS (n =114)	*p*-value
Age (year)	66 ± 9.7	66 ± 8.2	66 ± 11.1	.737
Graft age, year	9.9 ± 5.8	10.0 ± 5.6	9.8 ± 6.0	.768
Male, n (%)	181 (78)	92 (78)	89 (78.1)	.985
LVEF, %	49 ± 19	50 ± 20	45 ± 10	.123
Diabetes mellitus, n (%)	112 (48.3)	51 (43.2)	61 (53.5)	.075
Hypertension, n (%)	156 (67.2)	76 (64.4)	80 (70.2)	.430
Hyperlipidemia, n (%)	54 (23.3)	27 (22.9)	27 (23.7)	.885
History of congestive heart failure, n (%)	66 (28.4)	31 (26.3)	35 (30.7)	.455
Previous cerebrovascular accident, n (%)	5 (2.2)	4 (3.4)	1 (0.9)	.370
Smoking, n (%)	56 (24.1)	28 (24.6)	28 (23.7)	.882
STEMI, n (%)	20 (8.6)	6 (5.1)	14 (12.3)	.062
NSTEMI, n (%)	212 (91.4)	112 (94.9)	100 (87.7)	.086
Medications At Discharge n (%)				
Aspirin	224 (96.6)	112 (94.9)	112 (98.2)	.281
Clopidogrel	192 (82.8)	99 (83.9)	93 (81.6)	.729
Ticagrelor	34 (14.7)	18 (15.3)	16 (14)	.793
Prasugrel	7 (3)	2 (1.7)	5 (4.4)	.231
ACEIs or ARBs	200 (86.2)	95 (80.5)	105 (92.1)	**.013**
B-blocker	228 (98.3)	115 (97.5)	113 (99.1)	.330
Statins	212 (91.4)	107 (90.7)	105 (92.1)	.816
Spironolactone	22 (9.5)	13 (11)	9 (7.9)	.417

Continuous data are expressed as percentage, mean± standard deviation, or median± interquartile ranges. Categorical data are expressed as number (percentage)
LVEF: Left ventricular ejection fraction; STEMI: ST segment elevation myocardial infarction; NSTEMI: Non-ST segment elevation myocardial infarction; ACEIs: Angiotensin-converting enzyme inhibitors; ARBs: Angiotensin II receptor blockers

consistent with acute myocardial ischaemia and persistent ST segment depression or elevation.

Statistical Analysis

The data were analysed using the SPSS 22.0 statistical program (SPSS; IBM, Armonk, NY, USA). The Kolmogorov-Smirnov test was utilized to assess the normality of the distribution. The continuous variables were presented as mean ± standard deviation (normal distribution) or median with interquartile ranges (non-normal distribution), and the categorical variables were presented as the numbers of patients and percentages. A comparison between groups was made with the Student's *t*-test for the normally distributed variables and the Mann–Whitney U test for the variables with non-normal distribution. The categorical data from both groups were compared using the χ^2 or Fisher's exact tests.

The assessment of the collinearity between the pre-PCI CSS and the post-PCI CSS indicated a high correlation between them. Therefore, to assess the association between both the pre-PCI CSS and the post-PCI CSS and the five-year rates of the primary endpoint, multivariable Cox regression analyses were separately performed. The cumulative event rates at five years were estimated using the Kaplan-Meier method, and the comparison between the CSSs was made using the log-rank test. A p-value < .05 (using a two-sided test) was accepted as significant.

Results

A total of 232 AMI patients with previous CABG surgery who underwent PCI of SVG constituted the final study population. Based on the median of the pre-PCI CSS, the patients were divided into low pre-PCI CSS and high pre-PCI CSS groups. The low pre-PCI CSS group comprised 118 patients (50.8%), and 114 patients (49.2%) comprised the high pre-PCI CSS group. The baseline characteristics of the study groups were shown in Table I. The mean age of the study group patients was 66 ± 9.7 years, and most of the patients (78%) were male. The mean graft age was 9.9 ± 5.8 years. The LVEF was similar in both groups. There were no significant differences between the study groups regarding a history of HT, DM, HL, CHF and previous CVA. Similarly, there were no differences between the groups concerning smoking habits. The proportions of STEMI and NSTEMI were also similar between the groups.

Table II. Comparison of angiographic and PCI characteristics according to pre-PCI CSS of the study population.

	All Group (n=232)	Low pre-PCI CSS (n = 118)	High pre-PCI CSS (n =114)	*p*-value
Culprit SVG intervention				
SVG-LAD	16 (6.9)	6 (5.1)	10 (8.8)	.268
Diagonal artery	26 (11.2)	17 (14.4)	9 (7.9)	.116
Circumflex artery	90 (38.8)	39 (33.1)	51 (44.7)	.068
Right coronary artery	100 (43.1)	56 (47.5)	44 (38.6)	.187
Bypass graft analyze				
LIMA-LAD	208 (89.7)	113 (95.8)	95 (83.3)	**.002**
SVG-LAD	24 (10.3)	5 (4.2)	19 (16.7)	**.002**
SVG-D	110 (47.4)	54 (45.8)	56 (49.1)	.693
SVG-CX	196 (84.5)	102 (86.4)	94 (82.5)	.402
SVG-RCA	198 (85.3)	105 (89.0)	93 (81.6)	.111
Total no. of grafts				
1 Grafts	4 (1.7)	1 (0.8)	3 (2.6)	.297
2 Grafts	38 (16.4)	14 (11.9)	24 (21.1)	.076
3 Grafts	104 (44.8)	62 (52.5)	42 (36.8)	**.016**
4 Grafts	86 (37.1)	41 (34.7)	45 (37.1)	.456
LIMA graft failure	21 (9.3)	1 (0.9)	20 (17.5)	**< .001**
Bare-Metal stent	111 (47.8)	51 (43.2)	60 (52.6)	.189
Drug-Eluting Stent	121(52.2)	67 (56.8)	54 (47.4)	.151
Glycoprotein IIb/IIIa receptor antagonist use	26 (11.2)	11 (9.3)	15 (13.2)	.408
No-reflow	48 (20.7)	20 (16.9)	28 (24.7)	.195
Procedural success	205 (88.4)	108 (91.5)	97 (85.1)	.153
Pre-PCI CSS	20 ± 9.5	14.5 ± 6.5	24.5 ± 5.6	**<.001**
Post-PCI CSS	17.5 ± 9.5	12.5 ± 6.6	22 ± 5.1	**<.001**

Continuous data are expressed as percentage, mean± standard deviation, or median± interquartile ranges. Categorical data are expressed as number (percentage). SVG: Saphenous vein graft; LAD: Left anterior descending artery; LIMA: Left Internal mammary artery; D: Diagonal artery; CX: Circumflex artery; RCA: Right coronary artery; CSS: Coronary artery bypass graft SYNTAX score; PCI: Percutaneous coronary intervention

As shown in Table I, there were no significant differences between the study groups in terms of prescribed medications at discharge, except for angiotensin-converting enzyme inhibitors (ACEIs) or angiotensin receptor blockers (ARBs). In the high pre-PCI CSS group, ACEIs or ARBs were prescribed more frequently than in the low pre-PCI CSS group (p = .013) (Table I).

The angiographic and PCI features of the study population and the comparison of the two groups were shown in Table II. There were no differences between the two groups in terms of culprit SVG localisation that underwent PCI. Of the 232 patients in the current study 208 (89.7%) had LİMA graft for LAD, remaining 24 patients had saphenous vein graft for LAD. The total numbers of bypass grafts per patient were similar in the two groups except for patients who had been performed 3 grafts. The patients who had been performed 3 grafts were more common in the low pre-PCI CSS group (p = .016).

LIMA graft failure was more frequent in the high pre-PCI CSS group (p < .001). There were no patients who had undergone native LAD intervention in the during the index procedure. There were no differences between the groups regarding stent type used during PCI. The use of glycoprotein IIb/IIIa receptor antagonists during the procedure, the no-reflow rates and the procedural success rates also were similar between the two groups. In the high pre-PCI CSS group, the post-PCI CSS was higher compared to the low pre-PCI CSS group. The median pre-PCI CSS was 20 ± 9.5, and the median post-PCI CSS was 17.5 ± 9.5 (Table II).

The patients were followed up for a median time of 48 ± 36 months. The composite criteria of all-cause death/CVA/non-fatal MI were observed in 107 patients (46.1%) and the composite criteria of all-cause death/CVA in 90 patients (38.8%). Taken individually during the follow-up period, there were 84 all-cause deaths (36.2%), 51 cardiovascular deaths (22%), 6 CVAs (2.6%) and 16 non-fatal MIs (6.9%). The incidence of the composite criteria of all-cause death/CVA/non-fatal MI was significantly higher among the patients with a high pre-PCI CSS (p < .001). The incidence of all-cause death (p = .003) and cardiovascular death (p

Table III. Comparison of follow up time and major adverse cardiac events according to the pre-PCI CSS.

	All Group (n=232)	Low pre-PCI CSS (n = 118)	High pre-PCI CSS (n =114)	*p*-value
Follow-up time, months	48 ± 36	48 ± 36	48 ± 24	.589
Composite criteria all cause death/CVA/nonfatal MI	107 (46.1)	40 (33.9)	58.8 (67)	**<.001**
Composite criteria all cause death/CVA	90 (38.8)	34 (28.8)	56 (49.1)	**.002**
All cause death	84 (36.2)	32 (27.1)	52 (45.6)	**.003**
Cardiovascular death	51 (22)	17 (14.4)	34 (29.8)	**.005**
Cerebrovascular accident	6 (2.6)	2 (1.7)	4 (3.5)	.384
Nonfatal myocardial infarction	16 (6.9)	5 (4.2)	11 (9.6)	.104

= .005) was higher in the high pre-PCI CSS group. In addition, the incidence of CVA and non-fatal MI was higher in the group with a high pre-PCI CSS, although no statistical difference was found. Table III demonstrates that no statistically significant difference was found between the low pre-PCI CSS and high pre-PCI CSS groups for CVA (1.7% *vs.* 3.5%, $p = .384$ and for non-fatal MI 4.2% *vs.* 9.6%, $p = .104$, respectively).

Multivariable Cox regression analyses were performed to assess the association between both the pre-PCI CSS and the post-PCI CSS and the five-year rates of the primary endpoint. Table IV shows that LVEF (HR = 0.980, 95% CI = 0.962–0.999, $p = .035$), DM (HR = 1.875, 95% CI = 1.197–2.938, $p = .006$), no-reflow (HR = 1.718, 95% CI = 1.063–2.776, $p = .027$) and a high pre-PCI CSS (HR = 1.678, 95% CI = 1.082–2.602, $p = .021$) were significantly associated with the primary endpoint. As shown in Table V, post-PCI CSS was also an independent factor for the composite criteria of all-cause death/CVA/non-fatal MI (HR = 1.663, 95% CI = 1.066–2.596, $p = .025$).

Evaluation of the collinearity between pre-PCI CSS and post-PCI CSS indicated a high correlation between the two ($r = .835$; $p < .001$; Figure 1).

The Kaplan–Meier cumulative curves divided by the median of the pre-PCI CSS demonstrated that, compared with the low pre-PCI CSS group, the high-score group was associated at five years with higher composite criteria of all-cause death/CVA/non-fatal MI (low, 40.3%; high, 57.8%; $p = .015$), and the composite criteria of all-cause death/CVA (low, 29.5%; high, 47.2%; $p = .027$) (Figures 2 and 3).

Discussion

This study demonstrated that patients with a high pre-PCI CSS had higher rates of the composite criteria of all-cause death/CVA/non-fatal MI compared to the patients with a low pre-PCI CSS. To our knowledge, this is the first study which evaluates the long-term prognostic value of the pre-PCI CSS and its association with the compos-

Table IV. Cox regression analysis for prediction of composite of all-cause death, cerebrovascular accident and nonfatal myocardial infarction.

	Hazard ratio (95% CI)	*p*-value
Age	1.008 (0.986- 1.031)	.472
LVEF	0.980 (0.962- 0.999)	**.035**
STEMI	1.504 (0.757- 2.990)	.244
NSTEMI	0.814 (0.515- 1.288)	.380
Smoking	1.246 (0.741- 2.095)	.407
Diabetes mellitus	1.875 (1.197- 2.938)	**.006**
Hypertension	1.070 (0.689- 1.662)	.763
Hyperlipidemia	1.118 (0.690- 1.812)	.651
LIMA graft failure	0.730 (0.367- 1.542)	.370
Glycoprotein IIb/IIIa receptor antagonist use	1.201 (0.649-2.224)	.560
No-reflow	1.718 (1.063-2.776)	**.027**
Procedural success	0.616 (0.324-1.173)	.141
High pre-PCI CSS (>20)	1.678 (1.082-2.602)	**.021**

LVEF: Left ventricular ejection fraction; STEMI: ST segment elevation myocardial infarction; NSTEMI: Non-ST segment elevation myocardial infarction; IMA: Left Internal mammary artery; CSS: Coronary artery bypass graft SYNTAX score.

Table V. Cox regression analysis for prediction of composite of all-cause death, cerebrovascular accident, and nonfatal myocardial infarction.

	Hazard ratio (95% CI)	*p*-value
Age	1.008 (0.986-1.031)	.486
LVEF	0.979 (0.961-0.998)	**.027**
STEMI	1.375 (0.757-2.990)	.372
NSTEMI	0.814 (0.683-2.769)	.380
Smoking	0.799 (0.502-1.272)	.344
Diabetes mellitus	1.782 (1.133-2.802)	**.012**
Hypertension	1.082 (0.692-1.690)	.730
Hyperlipidemia	1.097 (0.674-1.785)	.710
LIMA graft failure	0.821 (0.420-1.604)	.563
Glycoprotein IIb / IIIa receptor antagonist use	1.107 (0.590-2.079)	.751
No-reflow	1.713 (1.055-2.780)	**.029**
Procedural success	0.541 (0.285-1.028)	.061
High post-PCI CSS (>18)	1.663 (1.066-2.596)	**.025**

LVEF: Left ventricular ejection fraction; STEMI: ST segment elevation myocardial infarction; NSTEMI: Non-ST segment elevation myocardial infarction; IMA: Left Internal mammary artery; CSS: Coronary artery bypass graft SYNTAX score.

ite criteria of all-cause death/CVA/non-fatal MI in patients who underwent PCI of SVG.

SVG is widely used in patients undergoing CABG due to its easy accessibility and the need for multiple grafts[3]. SVG's low 10-year patency rate limits the long-term success of surgical coronary revascularisation[15]. SVG failure has been commonly observed due to complex coronary pathology such as remodelling, progressive intimal hyperplasia and atherosclerosis in the long term[16,17]. SVG PCIs constitute approximately 5.7-6.1% of the total PCI cases[18,19], but its ef-

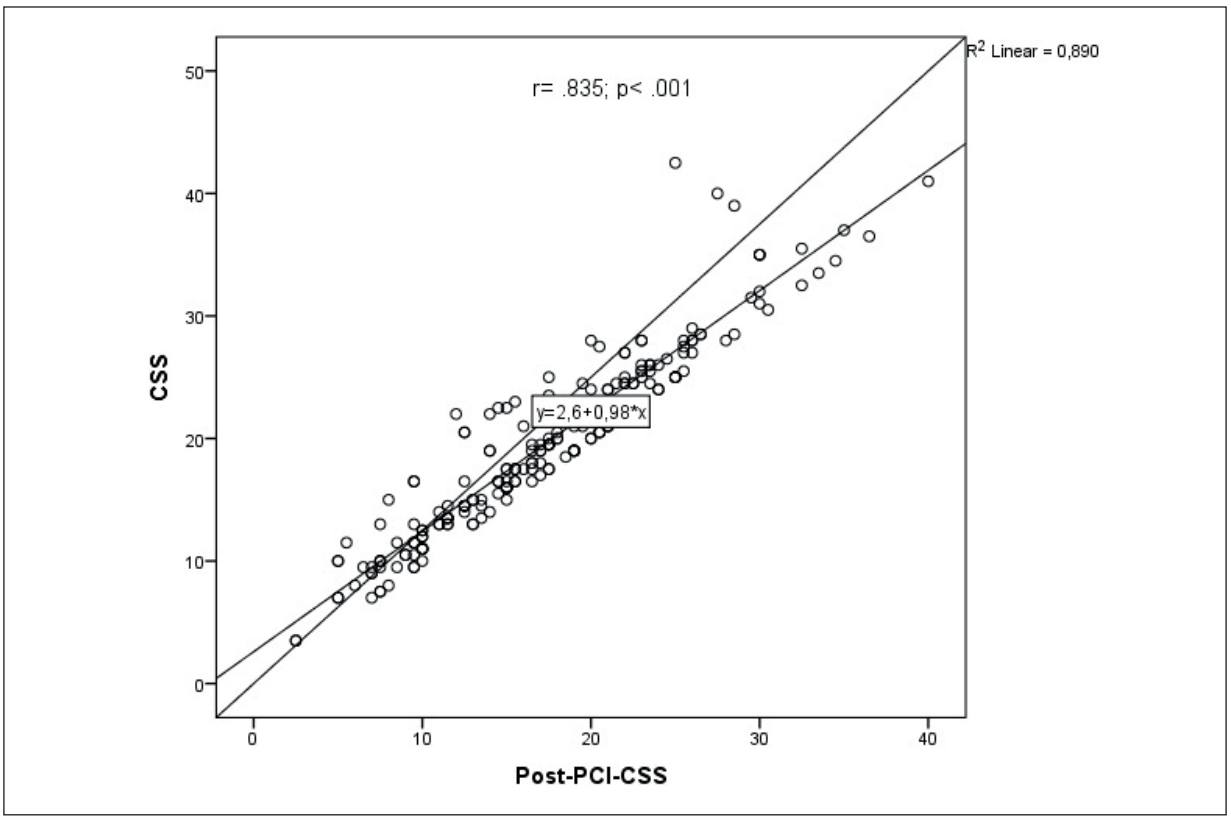

Figure 1. Correlation Between pre-PCI CSS and post-PCI CSS.

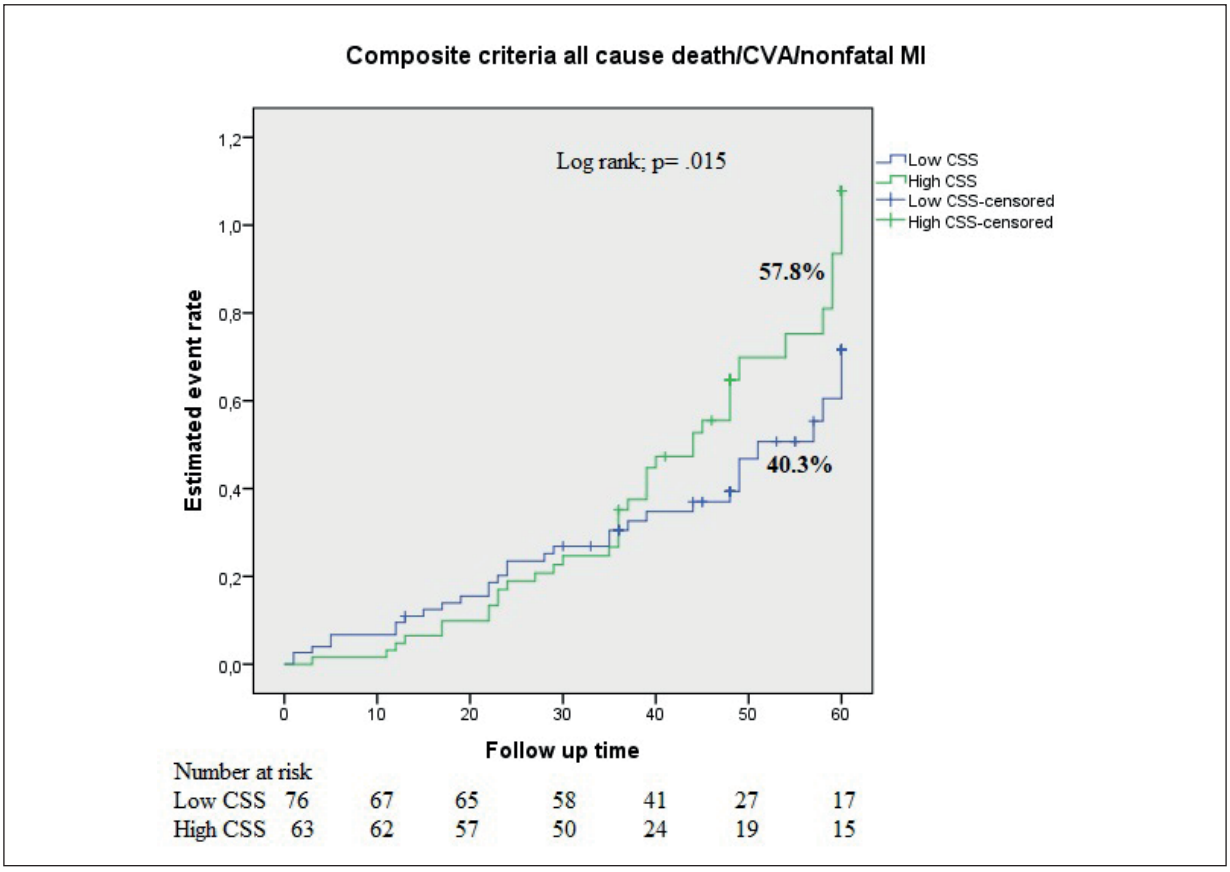

Figure 2. Kaplan-Meier Curve Showing Composite criteria all cause death/CVA/MI Rate through follow-up time.

ficacy remains controversial in relation to their long-term clinical outcomes[20]. It was shown that the complex coronary pathology as assessed by the SYNTAX score is not predictive for long-term adverse events in prior CABG patients[6,7]. Conventional powerful predictors of cardiovascular outcomes after CABG surgery include age, diabetes, LVEF and renal failure[21-23], which are not included in the SYNTAX score. Therefore, it has been suggested that the CSS could be used to evaluate complex coronary pathology and revascularisation status in patients who have undergone previous CABG[24]. This study investigated the prognostic value of the pre-PCI CSS in previous CABG patients who underwent PCI of SVG. Patients with a high pre-PCI CSS had a higher prevalence of the composite criteria of all-cause death/CVA/non-fatal MI compared to patients with a low CSS, despite similar baseline clinical and demographic characteristics.

Mortality increases significantly as SVGs lose their patency in patients with a previous CABG[25]. PCI is generally preferred as the revascularisation method, considering the concomitant comorbidities and high risk of reoperation in prior CABG patients[9]. In the present study, 232 patients had undergone PCI of SVG, and in 88.4% of cases angiographic success was achieved. As shown in Table II, it was observed that the patients with a high pre-PCI CSS group were more frequently associated with LIMA graft failure. The pre-PCI CSS may be a sign of more extensive atherosclerosis in both native coronary artery and progression of venous graft failure. Recent studies have reported that both the CSS and the post-PCI CSS have prognostic value in patients with prior CABG[9,12]. Considering previous data showing that residual myocardial ischaemia after PCI was associated with clinical outcomes[26,27], the CSS may be used to evaluate the prospective risk for previous CABG surgery patients who underwent PCI.

Miyagi et al[12] reported that patients with a high CSS had lower LVEF and a higher prevalence of heart failure, peripheral artery disease, CKD and older bypass grafts. On the contrary, in our study, the patients with a high pre-PCI CSS had similar comorbidities. This suggests that the pre-PCI CSS

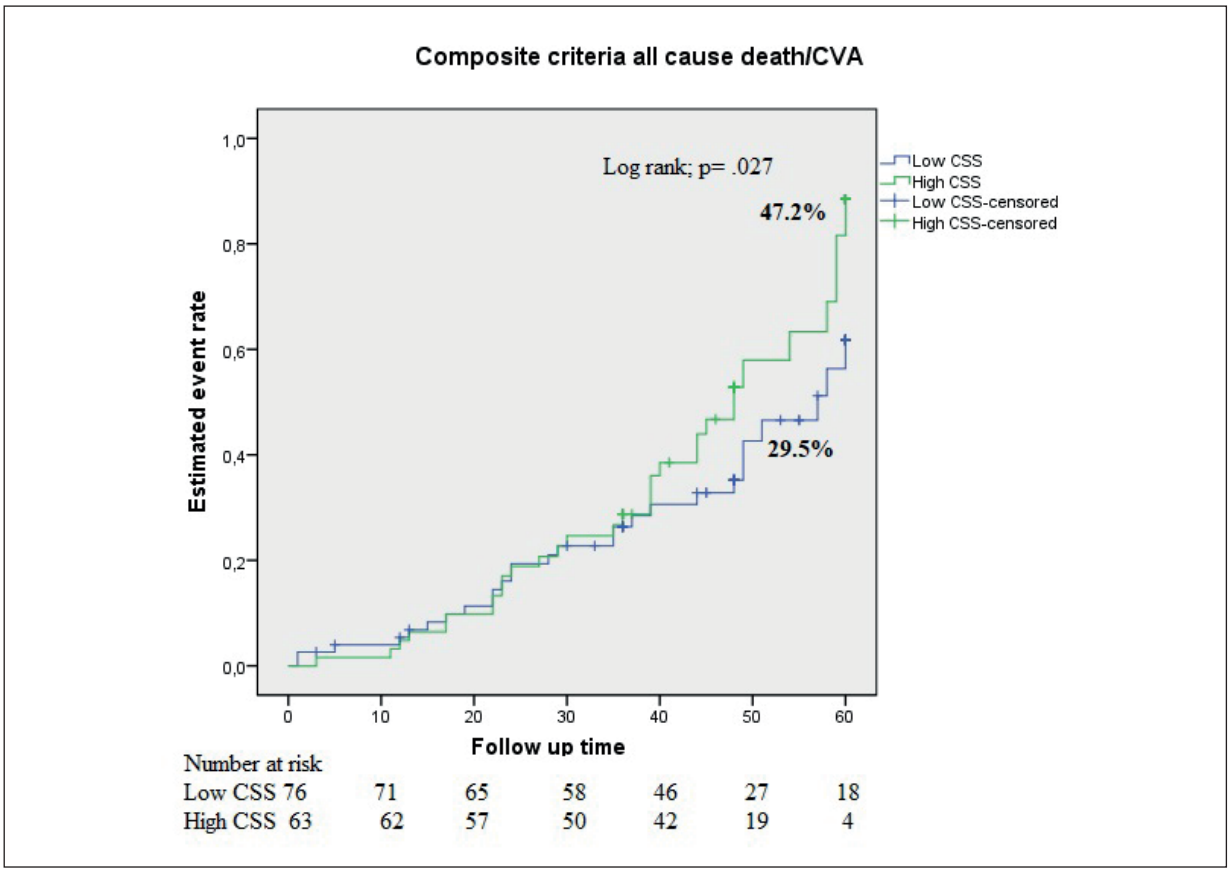

Figure 3. Kaplan-Meier Curve Showing Composite criteria all cause death/CVA Rate through follow-up time.

might help predict long-term prognosis, regardless of accompanying comorbidity.

Farooq et al[8] found that the CSS was associated with adverse events in 115 patients who underwent coronary angiography 15 months after surgery. In the present study, the evaluation time of the CSS after CABG was longer and CSS was calculated from angiographic images of patients taken performed after admission with AMI.

The patients with a high pre-PCI CSS had a higher prevalence of LIMA graft failure compared to the patients with a low pre-PCI CSS; however, this was not a significant predictor of clinical outcomes in the long term. The long-term patency of the grafts used during CABG is a major factor in the estimation of clinical outcomes[2]. The shear stress of the arterial lumen is a reason for the release of nitric oxide and prostaglandins and the inhibition of constricting mechanisms[28]. These biochemical factors make the arterial wall more resistant to high arterial pressure and atherosclerosis[29].

CSS represents the native coronary atherosclerotic burden as well as the incompleteness of coronary revascularization in patients with prior CABG.

The long-term clinical outcomes of patients treated with surgical revascularisation have been associated with the high prevalence and severity of traditional risk factors[30]. Our findings are similar to other studies showing that other risk factors, such as DM and LVEF in particular, play an important role in long-term prognosis[23,30].

This study has several limitations. The small number of patients limited the power of the study. Our trial has a reduced sample as part of a retrospective observational study, and this is a significant limitation. The CSS does not describe the type of graft anastomosed or the type of graft disease. In addition, the CSS does not include compliance with discharge medication, which affects patients' long-term outcomes. The present study was a retrospective, non-randomised study in which unmeasured confounders may have influenced the outcomes. More extensive studies are needed to confirm these observational results.

Conclusions

The present findings indicate that the pre-PCI CSS denoting burden of atherosclerotic is a significant prognostic factor for the long-term composite criteria of all-cause death/CVA/non-fatal MI in patients with previous CABG who underwent PCI of SVG.

Ethics Approval

The study was approved by the Local Ethics Committee of the Turkiye Yuksek Ihtisas Education and Research Hospital, Ankara, Turkey (799-2018).

Informed Consent

Informed consent was not required due to the retrospective nature of the study.

Availability of Data and Material

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this article.

Funding

None.

Authors' Contributions

Özge Çakmak Karaaslan: project development, data collection, manuscript writing and editing. Özge Çakmak Karaaslan, Orhan Maden: data analysis and interpretation, manuscript writing and editing. Mehmet Timur Selçuk, Hatice Selçuk: data collection, reviewed manuscript. Yücel Kanal, İdris Yakut, Nezaket Merve Yaman, Hasan Can Könte: data collection.

ORCID ID

Özge Çakmak Karaaslan: 0000-0003-0173-4017
Orhan Maden: 0000-0003-3170-1179
Yücel Kanal: 0000-0003-0934-0266
İdris Yakut: 0000-0002-3038-3829
Nezaket Merve Yaman: 0000-0002-9665-2673
Hasan Can Könte: 0000-0001-9321-5673
Mehmet Timur Selçuk: 0000-0002-1068-5619
Hatice Selçuk: 0000-0002-4900-5131

References

1) Serruys PW, Morice MC, Kappetein AP, Colombo A, Holmes DR, Mack MJ, Ståhle E, Feldman TE, van den Brand M, Bass EJ, Van Dyck N, Leadley K, Dawkins KD, Mohr FW. Percutaneous coronary intervention versus coronary-artery bypass grafting for severe coronary artery disease. N Engl J Med 2009; 360: 961-972.
2) Benedetto U, Raja SG, Albanese A, Amrani M, Biondi-Zoccai G, Frati G. Searching for the second best graft for coronary artery bypass surgery: a network meta-analysis of randomized controlled trials. Eur J Cardiothorac Surg 2015; 47: 59-65.
3) Lopes RD, Hafley GE, Allen KB, Ferguson TB, Peterson ED, Harrington RA, Mehta RH, Gibson CM, Mack MJ, Kouchoukos NT, Califf RM, Alexander JH. Endoscopic versus open vein-graft harvesting in coronary-artery bypass surgery. N Engl J Med 2009; 361: 235-244.
4) Waheed A, Klosterman E, Lee J, Mishra A, Narasimha V, Tuma F, Bokhari F, Haq F, Misra S. Assessing the Long-term Patency and Clinical Outcomes of Venous and Arterial Grafts Used in Coronary Artery Bypass Grafting: A Meta-analysis. Cureus 2019; 11: e5670.
5) Mohr FW, Morice MC, Kappetein AP, Feldman TE, Ståhle E, Colombo A, Mack MJ, Holmes DR Jr, Morel MA, Van Dyck N, Houle VM, Dawkins KD, Serruys PW. Coronary artery bypass graft surgery versus percutaneous coronary intervention in patients with three-vessel disease and left main coronary disease: 5-year follow-up of the randomised, clinical SYNTAX trial. Lancet 2013; 381: 629-638.
6) Serruys PW, Onuma Y, Garg S, Sarno G, van den Brand M, Kappetein AP, Van Dyck N, Mack M, Holmes D, Feldman T, Morice MC, Colombo A, Bass E, Leadley K, Dawkins KD, van Es GA, Morel MA, Mohr FW. Assessment of the SYNTAX score in the Syntax study. EuroIntervention 2009; 5: 50-56.
7) Chakravarty T, Buch MH, Naik H, White AJ, Doctor N, Schapira J, Mirocha JM, Fontana G, Forrester JS, Makkar R. Predictive accuracy of SYNTAX score for predicting long-term outcomes of unprotected left main coronary artery revascularization. Am J Cardiol 2011; 107: 360-366.
8) Farooq V, Girasis C, Magro M, Onuma Y, Morel MA, Heo JH, Garcia-Garcia H, Kappetein AP, van den Brand M, Holmes DR, Mack M, Feldman T, Colombo A, Ståhle E, James S, Carrié D, Fournial G, van Es GA, Dawkins KD, Mohr FW, Morice MC, Serruys PW. The CABG SYNTAX Score - an angiographic tool to grade the complexity of coronary disease following coronary artery bypass graft surgery: from the SYNTAX Left Main Angiographic (SYNTAX-LE MANS) substudy. EuroIntervention 2013; 8: 1277-1285.
9) Takahashi K, Thuijs D, Hara H, Wang R, Mohr FW, Morice MC, Holmes DR, Jr., Kappetein AP, Head SJ, Onuma Y, Serruys PW. Impact of the CABG SYNTAX score on all-cause death at 10 years: a SYNTAX Extended Survival (SYNTAXES) substudy. EuroIntervention 2021; 17: 75-77.
10) Kim YH, Park DW, Lee JY, Kim WJ, Yun SC, Ahn JM, Song HG, Oh JH, Park JS, Kang SJ, Lee SW, Lee CW, Park SW, Park SJ. Impact of angiographic complete revascularization after drug-eluting stent implantation or coronary artery bypass graft surgery for multivessel coronary artery disease. Circulation 2011; 123: 2373-2381.
11) Scarsini R, Zivelonghi C, Pesarini G, Vassanelli C, Ribichini FL. Repeat revascularization: Percutaneous cor-

onary intervention after coronary artery bypass graft surgery. Cardiovasc Revasc Med 2016; 17: 272-278.
12) Miyagi T, Asaumi Y, Nishimura K, Nakashima T, Sakamoto H, Nakao K, Kanaya T, Nagai T, Shimabukuro Y, Miyamoto Y, Fujita T, Kusano K, Anzai T, Kobayashi J, Noguchi T, Ogawa H, Yasuda S. Validation of the Coronary Artery Bypass Graft SYNTAX Score (Synergy Between Percutaneous Coronary Intervention With Taxus) as a Prognostic Marker for Patients With Previous Coronary Artery Bypass Graft Surgery After Percutaneous Coronary Intervention. Circ Cardiovasc Interv 2016; 9: e003459.
13) Sim DS, Jeong MH, Ahn Y, Kim YJ, Chae SC, Hong TJ, Seong IW, Chae JK, Kim CJ, Cho MC, Seung KB, Park SJ, Korea Acute Myocardial Infarction Registry I. Effectiveness of drug-eluting stents versus bare-metal stents in large coronary arteries in patients with acute myocardial infarction. J Korean Med Sci 2011; 26: 521-527.
14) Thygesen K, Alpert JS, Jaffe AS, Chaitman BR, Bax JJ, Morrow DA, White HD. Fourth Universal Definition of Myocardial Infarction (2018). J Am Coll Cardiol 2018; 72: 2231-2264.
15) Lee MS, Park SJ, Kandzari DE, Kirtane AJ, Fearon WF, Brilakis ES, Vermeersch P, Kim YH, Waksman R, Mehilli J, Mauri L, Stone GW. Saphenous vein graft intervention. JACC Cardiovasc Interv 2011; 4: 831-843.
16) Caliskan E, de Souza DR, Böning A, Liakopoulos OJ, Choi YH, Pepper J, Gibson CM, Perrault LP, Wolf RK, Kim KB, Emmert MY. Saphenous vein grafts in contemporary coronary artery bypass graft surgery. Nat Rev Cardiol 2020; 17: 155-169.
17) Ferrari G, Geijer H, Cao Y, Souza D, Samano N. Percutaneous coronary intervention in saphenous vein grafts after coronary artery bypass grafting: a systematic review and meta-analysis. Scand Cardiovasc J 2021; 55: 245-253.
18) Brilakis ES, Wang TY, Rao SV, Banerjee S, Goldman S, Shunk K, Kar B, Holmes DR, Jr., Dai D, Chin CT, Harding TM, Roe MT. Frequency and predictors of drug-eluting stent use in saphenous vein bypass graft percutaneous coronary interventions: a report from the American College of Cardiology National Cardiovascular Data CathPCI registry. JACC Cardiovasc Interv 2010; 3: 1068-1073.
19) Brilakis ES, Rao SV, Banerjee S, Goldman S, Shunk KA, Holmes DR, Jr., Honeycutt E, Roe MT. Percutaneous coronary intervention in native arteries versus bypass grafts in prior coronary artery bypass grafting patients: a report from the National Cardiovascular Data Registry. JACC Cardiovasc Interv 2011; 4: 844-850.
20) Redfors B, Généreux P, Witzenbichler B, McAndrew T, Diamond J, Huang X, Maehara A, Weisz G, Mehran R, Kirtane AJ, Stone GW. Percutaneous Coronary Intervention of Saphenous Vein Graft. Circ Cardiovasc Interv 2017; 10.
21) Hillis GS, Croal BL, Buchan KG, El-Shafei H, Gibson G, Jeffrey RR, Millar CG, Prescott GJ, Cuthbertson BH. Renal function and outcome from coronary artery bypass grafting: impact on mortality after a 2.3-year follow-up. Circulation 2006; 113: 1056-1062.
22) Hillis GS, Zehr KJ, Williams AW, Schaff HV, Orzulak TA, Daly RC, Mullany CJ, Rodeheffer RJ, Oh JK. Outcome of patients with low ejection fraction undergoing coronary artery bypass grafting: renal function and mortality after 3.8 years. Circulation 2006; 114: I414-419.
23) Melina G, Angeloni E, Refice S, Benegiamo C, Lechiancole A, Matteucci M, Roscitano A, Bianchini R, Capuano F, Comito C, Spitaleri P, Tonelli E, Speciale G, Pristipino C, Monti F, Serdoz R, Paneni F, Sinatra R. Residual SYNTAX score following coronary artery bypass grafting. Eur J Cardiothorac Surg 2017; 51: 547-553.
24) Morice MC, Feldman TE, Mack MJ, Ståhle E, Holmes DR, Colombo A, Morel MA, van den Brand M, Serruys PW, Mohr F, Carrié D, Fournial G, James S, Leadley K, Dawkins KD, Kappetein AP. Angiographic outcomes following stenting or coronary artery bypass surgery of the left main coronary artery: fifteen-month outcomes from the synergy between PCI with TAXUS express and cardiac surgery left main angiographic substudy (SYNTAX-LE MANS). EuroIntervention 2011; 7: 670-679.
25) Iqbal J, Zhang YJ, Holmes DR, Morice MC, Mack MJ, Kappetein AP, Feldman T, Stahle E, Escaned J, Banning AP, Gunn JP, Colombo A, Steyerberg EW, Mohr FW, Serruys PW. Optimal medical therapy improves clinical outcomes in patients undergoing revascularization with percutaneous coronary intervention or coronary artery bypass grafting: insights from the Synergy Between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery (SYNTAX) trial at the 5-year follow-up. Circulation 2015; 131: 1269-1277.
26) Farooq V, Serruys PW, Bourantas CV, Zhang Y, Muramatsu T, Feldman T, Holmes DR, Mack M, Morice MC, Ståhle E, Colombo A, de Vries T, Morel MA, Dawkins KD, Kappetein AP, Mohr FW. Quantification of incomplete revascularization and its association with five-year mortality in the synergy between percutaneous coronary intervention with taxus and cardiac surgery (SYNTAX) trial validation of the residual SYNTAX score. Circulation 2013; 128: 141-151.
27) Shaw LJ, Berman DS, Maron DJ, Mancini GB, Hayes SW, Hartigan PM, Weintraub WS, O'Rourke RA, Dada M, Spertus JA, Chaitman BR, Friedman J, Slomka P, Heller GV, Germano G, Gosselin G, Berger P, Kostuk WJ, Schwartz RG, Knudtson M, Veledar E, Bates ER, McCallister B, Teo KK, Boden WE. Optimal medical therapy with or without percutaneous coronary intervention to reduce ischemic burden: results from the Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation (COURAGE) trial nuclear substudy. Circulation 2008; 117: 1283-1291.
28) Webb CM, Moat NE, Chong CF, Collins P. Vascular reactivity and flow characteristics of radial artery and long saphenous vein coronary bypass grafts: a 5-year follow-up. Circulation 2010; 122: 861-867.
29) Zhang H, Wang ZW, Wu HB, Hu XP, Zhou Z, Xu P. Radial artery graft vs. saphenous vein graft for coronary artery bypass surgery : which conduit offers better efficacy? Herz 2014; 39: 458-465.
30) Myers WO, Blackstone EH, Davis K, Foster ED, Kaiser GC. CASS Registry long term surgical survival. Coronary Artery Surgery Study. J Am Coll Cardiol 1999; 33: 488-498.