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Original Article

Relevance of SYNTAX score for assessment of saphenous vein graft failure after coronary artery bypass grafting

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Abstract

Objective: To identify risk factors of saphenous vein graft (SVG) failure and to investigate the utility of anatomical SYNTAX score (SS) and SYNTAX score II (SS-II) in predicting SVG failure.

Methods: A total of 598 patients who underwent angiography for clinical reasons after coronary artery bypass grafting (CABG) were included. Baseline data and factors related to SVG failure were analyzed at the patient and graft levels. Patients were divided in tertiles by anatomical SS and in three groups by SS-II revascularization recommendation, and SVG patency was analyzed across these groups.

Results: Patency rates were similar in all SS-stratified and SS-II recommendation groups within 1, 5, and 10 years after CABG. At the patient level, fasting blood glucose (FBG) level <7.0 mmol/L was less common in SVG failure (68.0% *vs.* 76.2%). At the graft level, patients with SVG failure tended to have angiography later (4.0 years *vs.* 3.0 years), poorer FBG control (FBG <7.0 mmol/L: 68.2% *vs.* 74.7%), and more grafts anastomosed to the right coronary system (59.2% *vs.* 47.4%). Longer time interval after CABG was related to SVG failure both at the patient and graft levels, and odds ratio (*OR*)/*P* values (*OR*/*P*) were 1.282/0.029 and 1.384/0.016, respectively. Using independent graft and grafting to the right artery system as risk factors at the graft level, *OR*/*P*s were 3.094/0.000 and 2.524/0.000, respectively.

Conclusions: Longer time interval after CABG, independent grafts, and grafting to the right artery system are associated with SVG failure. Anatomical SS or SS-II may not be reasonable tools for predicting SVG failure.

Keywords: Coronary artery bypass grafting; Graft patency; Saphenous vein graft; SYNTAX score; Predictor

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Introduction

The saphenous vein graft (SVG) is a widely used conduit in coronary artery bypass grafting (CABG). Surgical success and clinical benefits for post-CABG patients largely rely on SVG patency[1,2] and understanding the risk factors of SVG failure may help to improve outcomes. Most studies[3−5] examined the predictors for SVG failure by data from other countries, but few used data from China. In this study, we used data from the Beijing Anzhen Hospital to identify risk factors of SVG failure at the patient and graft levels and to investigate the utility of anatomical SYNTAX score (SS) and SYNTAX score II (SS-II) in predicting SVG failure.

Materials and methods

Study population

A total of 598 post-CABG patients who underwent coronary and SVGs angiography for clinical reasons (angina, myocardial infarction) between January 1, 2003 and December 31, 2016 were enrolled in the study at Beijing Anzhen Hospital (Beijing, China). This study was approved by the Ethics committee of Beijing Anzhen Hospital. (LS2018-001). All the patients provided informed consent. Baseline data and factors related to SVG failure were analyzed at the patient level and the graft level.

Before CABG, anatomical SS was calculated to evaluate the coronary anatomy complexity and SS-II revascularization recommendation for each patient was recorded. At the graft level, all SVGs were stratified into three tertiles by anatomical SS: low score ($n = 375$), intermediate score ($n = 265$), and high score ($n = 161$). In each tertile, SVG patency at 1, 5, and 10 years was calculated based on the data collected from hospital records. Likewise, at the patient level, SVG patency was calculated in three groups classified by SS-II revascularization recommendation for percutaneous coronary intervention (PCI), PCI/CABG, and CABG, respectively.

Definitions

SVG failure was defined as ≥50% stenosis detected by angiography. For the graft with multiple segments, failure of any segment was considered SVG failure.

Anatomical SS and SS-II have been described in detail previously.[6] Briefly, the anatomical SS was calculated through the summation of the scores for each separate lesion detected on angiograms. Anatomical SS < 22 was defined as a low score, 23−32 as an intermediate score, and ≥33 as a high score. SS-II is based on anatomical SS and includes six additional clinical factors. If the difference in mortality risk prediction was in favor of CABG with a 95% confidence interval (*CI*), CABG was recommended for the patient. Likewise, if the difference in mortality risk prediction was in favor of PCI with 95% *CI*, PCI was recommended. If there was no significant difference in mortality rates with 95% *CI*, equipoise between PCI and CABG was recommended.[7] Both anatomical SS and SS-II in our study were calculated with the SYNTAX score online calculator (www.syntaxscore.com).

Abnormal triglyceride (TG) was defined as TG level ≥1.70 mmol/L. Good control of plasma glucose, lipids, and uric acid were defined as fasting blood glucose (FBG) level <7.0 mmol/L,[8] low-density lipoprotein cholesterol (LDL-C) level <1.8 mmol/L, and uric acid level <360 μmol/L, respectively.[9]

Statistical analysis

SPSS version 20.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Continuous variables were expressed as mean ± standard deviation or median (Q1−Q3) and were compared by Student's *t*-test or Mann−Whitney *U* test. Categorical variables were expressed as numbers (percentages) and were compared with Chi-squared or Fisher's exact tests. Multiple forward stepwise logistic regression was used to identify clinical and procedural characteristics associated with SVG failure. Variables associated with SVG failure (P value < 0.1) based on univariable logistic regression analysis were entered into the multivariate model. All P values were two-sided, and a P value < 0.05 was considered statistically significant.

Results

Patient population

A total of 598 patients were included of whom 77.9% (466/598) were male. The mean age was 61.5 ± 8.8 years. Among them, 60.4% (361/598) had SVG failure. At the graft level, 54.2% (434/801) of SVGs failed.

SVG patency rate

SVG patency decreased in all three tertiles with longer time interval after CABG (Table 1). No significant differences in SVG patency were detected either

Table 1
Saphenous vein graft patency in anatomical SYNTAX score tertiles ($n = 801$).

Time	Total	Anatomical SYNTAX score			*P* values
		Low	Intermediate	High	
1 year	75/143 (52.4)	30/54 (55.6)	30/58 (51.7)	15/31 (48.4)	0.81
5 years	250/512 (48.8)	115/229 (50.2)	82/167 (49.1)	53/116 (45.7)	0.73
10 years	345/730 (47.3)	162/343 (47.2)	116/239 (48.5)	67/148 (45.3)	0.82

Data are presented as the number of patent grafts/ the number of follow-up grafts (%).

among anatomical SS tertiles or SS-II recommendation groups (Tables 1 and 2).

Baseline characteristics

Comparisons of baseline characteristics at the patient and graft levels are shown in Tables 3 and 4, respectively. At the patient level, good glycemic control (FBG <7.0 mmol/L) was less common in SVG failure (65.9% *vs.* 74.3%). At the graft level, patients with SVG failure tended to have angiography later (4.0 years *vs.* 3.0 years), poorer glycemic control (FBG <7.0 mmol/L: 66.1% *vs.* 73.3%), and more grafts anastomosed to the right coronary system (59.2% *vs.* 47.4%). Independent grafts were more common in SVG failure (65.0% *vs.* 45.8%), whereas sequential SVG were less common in SVG failure (33.6% *vs.* 52.0%). All above-mentioned differences were statistically significant ($P < 0.05$).

Factors related to SVG failure

The variables with P value < 0.1 in univariable logistic regression analysis are listed in Tables 5 and 6 and were included in multiple logistic regression analysis. After adjusting for confounding factors, longer time interval after CABG was related to SVG failure both at the patient and graft levels and odds ratio/*P* values (*OR/P*) were 1.384/0.016 and 1.282/0.029, respectively. Using independent graft and grafting to the right artery system as risk factors at the graft level, *OR/P*s were 3.094/0.000 and 2.524/0.000, respectively. Independent grafts had a two-fold higher risk of failure than sequential grafts.

Discussion

This study aimed to identify risk factors of SVG failure and to investigate possible ability of anatomical SS and SS-II in predicting SVG failure.

SVG patency

SVG patency in anatomical SS tertiles and SS-II recommendation groups were all similar at different intervals after CABG.

As shown in Table 1, the overall patency rates (52.4%, 48.8% and 47.3%, respectively) were much lower than those previously reported,[10–12] mostly because included patients underwent coronary angiography for clinical reasons and they probably represented a subgroup with a high probability of significant lesions. Moreover, a cohort of symptom-free patients with SVG was not included in this study, which underestimates the patency rate. Although the P value was >0.05, patients with lowest anatomical SS had the highest patency, partly because of less complicated and diffuse lesions and slower progress of stenosis.

Table 2 shows that patients with equal recommendations for PCI/CABG had similar patency rates with those for whom CABG was recommended, suggesting that SS-II was ineffective to evaluate the SVG patency after CABG surgery or to predict occurrence of SVG failure. Due to few patients with PCI only

Table 2
Saphenous vein graft patency in three groups classified by SYNTAX score II treatment recommendation ($n = 598$).

Time	Total	SYNTAX score II treatment recommendation			*P* values
		PCI	PCI or CABG	CABG	
1 year	46/110 (41.9)	3/4 (75.0)	30/73 (41.1)	13/33 (39.4)	0.39
5 years	164/390 (42.1)	3/4 (75.0)	109/254 (42.9)	52/132 (39.4)	0.32
10 years	220/549 (40.1)	3/5 (60.0)	146/357 (40.9)	71/187 (38.0)	0.38

Data are presented as the number of patients with patent grafts/the number of follow-up patients (%). PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

Table 3
Baseline characteristics at the patient level (n=598).

Characteristics	Without SVG failure (n = 237)	With SVG failure (n = 361)	P value
Demographics			
Age, years, mean ± SD	61.3 ± 8.5	61.6 ± 8.9	0.630
Men, n (%)	191 (80.6)	275 (76.2)	0.200
BMI, kg/m^2, mean ± SD	26.4 ± 3.0	26.4 ± 2.9	0.910
Presentation, n (%)			0.080
Angina	219 (92.4)	321 (88.9)	
NSTEMI	18 (7.6)	36 (10.0)	
STEMI	0 (0)	4 (1.1)	
Years from CABG, years, median (Q1−Q3)	3.0 (1.0−5.0)	3.0 (1.0−7.0)	0.130
Comorbidities, n (%)			
Hypertension	162 (68.4)	252 (69.8)	0.710
Diabetes mellitus	95 (40.1)	157 (43.5)	0.410
Cerebral vascular disease	24 (10.1)	51 (14.1)	0.150
Prior myocardial infarction	72 (30.4)	112 (31.0)	0.870
Prior PCI	55 (23.2)	64 (17.7)	0.100
Peripheral vessel disease	18 (7.6)	33 (9.1)	0.510
Smoking, n (%)			0.250
Never	109 (46.0)	171 (47.4)	
Former	85 (35.9)	109 (30.2)	
Current	43 (18.1)	81 (22.4)	
Family history, n (%)	20 (8.4)	24 (6.6)	0.410
On-pump CABG, n (%)	24 (10.1)	48 (13.3)	0.240
Isolated CABG, n (%)	214 (90.3)	340 (94.2)	0.080
CABG surgical duration, hours, median (Q1−Q3)	4.0 (4.0−5.0)	4.0 (3.5−4.8)	0.220
Laboratory test			
Creatinine, μmol/L, mean ± SD	81.2 ± 18.4	78.7 ± 18.0	0.100
FBG <7.0 μmol/L, n (%)	176 (74.3)	238 (65.9)	0.030
UA <360 μmol/L, n (%)	127 (53.6)	190 (52.6)	0.890
TG ≥ 1.7 mmol/L, n (%)	89 (37.6)	151 (41.8)	0.200
CHOL, mmol/L, median (Q1−Q3)	3.88 (3.37−4.52)	3.89 (3.43−4.64)	0.260
HDL-C, mmol/L, median (Q1−Q3)	0.95 (0.83−1.12)	0.96 (0.83−1.12)	0.950
LDL-C <1.8 mmol/L, n (%)	50 (21.1)	71 (19.7)	0.770
Anatomical SYNTAX score, median (Q1−Q3)	23.0 (17.0−31.0)	24.0 (15.0−31.0)	0.790

SVG: saphenous vein graft; SD: standard deviation; BMI: body mass index; NSTEMI: non-ST elevation acute myocardial infarction; STEMI: ST elevation acute myocardial infarction; CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention; FBG: fasting blood glucose; UA: uric acid; TG: triglyceride; CHOL: total cholesterol; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol.

recommendation (n = 5), no reliable conclusion could be drawn from this subgroup.

Factors related to SVG failure

In logistic regression analysis, time interval after CABG was related to SVG failure, consistent with the idea that the likelihood of SVG failure increases over time after CABG. The cumulative effect of lesion becomes more obvious over time and results in SVG failure.

In graft-level logistic analysis, independent grafts had a two-fold higher risk of failure compared to sequential grafts, suggesting the disadvantage of independent graft regarding long-term outcomes. Previous studies had indicated that poor distal run-off was associated with graft failure and suggested using sequencing anastomosis to improve SVG flow.[13,14] This finding was supported by several studies.[15−19] However, some studies have demonstrated no difference,[20] while the data from the PREVENT IV trial showed higher 1-year SVG failure in sequential SVG.[21] The causes of these disparate findings may be explained by different levels of operation skills, surgical procedures, and bias in patient collection due to a lack of systematic follow-up angiography.

Earlier studies have shown that patency is generally lower in SVGs grafted to the right coronary system than those grafted to the left one.[22] This study identified such grafting as a risk factor for SVG failure. Right coronary system is located on the back and diaphragmatic sites of the heart and placing

Table 4
Baseline characteristics at the graft level (n=801).

Characteristics	Without SVG failure (n = 367)	With SVG failure (n = 434)	P value
Demographics			
Age, years, median (Q1–Q3)	62.0 (56.0–69.0)	62.0 (56.0–68.0)	0.600
Men, n (%)	282 (76.8)	329 (75.8)	0.730
BMI, kg/m^2, mean ± SD	26.4 ± 3.0	26.4 ± 3.0	0.750
Years from CABG, years, median (Q1–Q3)	3.0 (1.0–5.0)	4.0 (1.0–7.0)	0.040
Comorbidities, n (%)			
Hypertension	251 (68.4)	301 (69.4)	0.770
Diabetes mellitus	148 (40.3)	193 (44.5)	0.240
Cerebral vascular disease	45 (12.3)	56 (12.9)	0.790
Prior myocardial infarction	103 (28.1)	130 (30.0)	0.560
Prior PCI	78 (21.3)	70 (16.1)	0.060
Peripheral vessel disease	31 (8.4)	46 (10.6)	0.300
Smoking, n (%)			0.450
Never	184 (50.1)	200 (46.1)	
Former	112 (30.5)	137 (31.6)	
Current	71 (19.3)	97 (22.4)	
On-pump CABG, n (%)	48 (13.1)	62 (14.3)	0.620
Isolated CABG, n (%)	333 (90.7)	408 (94.0)	0.080
SVG type, n (%)			
Independent	168 (45.8)	282 (65.0)	<0.001
Sequential	191 (52.0)	146 (33.6)	<0.001
Composite	8 (2.2)	6 (1.4)	0.390
Grafting to right coronary system, n (%)	174 (47.4)	257 (59.2)	<0.001
Laboratory test			
Creatinine, μmol/l, mean ± SD	80.1 ± 19.2	78.5 ± 18.0	0.250
FBG <7.0 mmol/L	269 (73.3)	287 (66.1)	0.040
UA <360 μmol/L	195 (53.1)	230 (53.0)	0.950
TG ≥ 1.7 mmol/L	149 (40.6)	181 (41.7)	0.590
CHOL, mmol/L, median (Q1–Q3)	3.88 (3.40–4.65)	3.92 (3.45–4.66)	0.190
HDL-C, mmol/L, median (Q1–Q3)	0.96 (0.84–1.13)	0.95 (0.83–1.13)	0.700
LDL-C <1.8 mmol/L	75 (20.4)	80 (18.4)	0.560
Anatomical SYNTAX Score, median (Q1–Q3)	23.5 (18.0–31.5)	24.3 (15.9–31.5)	0.560

SVG: saphenous vein graft; SD: standard deviation; CABG: coronary artery bypass grafting; PCI: percutaneous coronary intervention; FBG: fasting blood glucose; UA: uric acid; TG: triglyceride; CHOL: total cholesterol; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol.

grafts requires turning back the heart during surgery. Perfect angles of anastomosis are difficult to achieve, grafts are more likely to be bent or squeezed, and blood flow can be affected, which can easily lead to SVG failure.

Traditional risk factors, including hypertension, diabetes mellitus, and smoking, were not found related to SVG failure in this study. Although poorer glycemic control was more common in patients with SVG failure in this study, good control of plasma glucose, lipids, and uric acid levels after CABG was not found to reduce the risk of SVG failure. Although the results of studies on biochemical indicators affecting SVG patency have been inconsistent, it is consensual that

Table 5
Factors related to patient-level saphenous vein graft failure.

Variables	Univariable analysis			Multivariable analysis		
	OR	95% *CI*	P value	*OR*	95% *CI*	P value
Isolated CABG	1.740	0.940–3.221	0.078	Not selected	–	–
Total cholesterol	1.145	0.979–1.339	0.090	Not selected	–	–
FBG <7.0 mmol/L	0.664	0.456–0.968	0.033	Not selected	–	–
Creatinine	0.992	0.983–1.001	0.099	Not selected	–	–
Years from CABG (every 5 years added)	1.067	1.017–1.120	0.009	1.384	1.063–1.801	0.016

OR: odds ratio; *CI*: confidence interval; CABG: coronary artery bypass grafting; FBG: fasting blood glucose.

Table 6
Factors related to graft-level saphenous vein graft failure.

Variables	Univariable analysis			Multivariable analysis		
	OR	95% *CI*	*P* value	*OR*	95% *CI*	*P* value
Prior PCI	0.713	0.498–1.019	0.063	Not selected	–	–
FBG <7.0 mmol/L	0.725	0.529–0.992	0.044	Not selected	–	–
Total cholesterol	1.126	0.990–1.282	0.071	Not selected	–	–
Graft type						
Sequential	Reference	–	–	Reference	–	–
Independent	2.196	1.647–2.929	<0.001	3.094	2.186–4.380	<0.001
Grafting to the right coronary system	1.611	1.217–2.132	0.001	2.524	1.793–3.554	<0.001
Years from CABG (every 5 years added)	1.366	1.112–1.678	0.003	1.282	1.026–1.603	0.029

PCI: percutaneous coronary intervention; FBG: fasting blood glucose; CABG: coronary artery bypass grafting; *OR*: odds ratio; *CI*: confidence interval.

traditional risk factors should be strictly controlled to improve clinical outcome after CABG.

Correlation between anatomical SS or SS-II and SVG failure

This study showed that neither anatomical SS tertiles, nor SS-II could effectively predict SVG failure. Anatomical SS and SS-II are mainly based on anatomical complexity of coronary arteries, but the occurrence of SVG failure might be complicated and several clinical and surgical factors should be considered in graft failure prediction. Therefore, anatomical SS and SS-II may not be reasonable for predicting SVG failure. More studies are needed to create effective tools for predicting SVG failure.

This study had several limitations. First, this was a single-center, retrospective study with a relatively small sample size. Patients underwent coronary angiography for clinical reasons and they probably represented a subgroup with a high probability of significant lesions. Owing to the lack of patients with SVG failure, but without clinical symptoms, the patency rate was affected. Second, some parameters, such as SVG harvest technique, target artery quality, and post-CABG medicinal prevention, were not assessed and the time when the SVG failure occurred was unknown, thus limiting the generalizability of our results.

Conclusions

The risk factors of SVG failure are longer time interval after CABG, use of independent grafts, and grafting to the right artery system. Anatomical SS and SS-II may not be reasonable tools for predicting SVG failure. Further investigations should be performed to improve SVG patency.

Conflicts of interest

The authors declare that they have no conflict of interest.

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