

Prognostic Value of Residual Syntax Score after Percutaneous Coronary Intervention in Multivessel Coronary Artery Disease

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Abstract

Background Residual SYNTAX (Synergy between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery) Score (RSS) is an objective measure for the assessment of degree and complexity of residual stenosis after the percutaneous coronary intervention (PCI).

Aim The study aimed at evaluating the role of angiographic complete (CR) and incomplete (ICR) revascularization on clinical outcomes in patients undergoing PCI for multivessel coronary artery disease (MVCAD). The study sought to investigate the role of initial and residual severity of coronary atherosclerosis in prognostication of patients with MVCAD who underwent PCI.

Material and Methods We retrospectively recruited 135 patients having MVCAD who underwent PCI. Coronary angiogram was used to assess the severity of coronary atherosclerosis. From the angiographic data baseline (BSS) and RSS were calculated. Subjects having a RSS of 0 were defined as having CR, and those having RSS > 0 are defined as ICR group. The study population was subgrouped into two groups as follows: CR, 0 ($n = 17$, 23%); ICR, >0 to 4 ($n = 89$, 47.2%). Clinical outcomes were measured, which included major adverse cardiac and cerebrovascular events (MACE) at 1 year.

Results Among the study subjects mean age was 57.25 ± 17.55 . About 76.3% were males, and 23.7% were females. About 89.4% had diabetes, 88.6% had hypertension as risk factors, and 95.8% were smokers.

The mean values of BSS and RSS were 20.2 ± 9.2 and 4.1 ± 7.0 , respectively. Based on RSS the individuals were divided into two groups as follows: CR, 0 ($n = 17$, 23%); ICR, > 0 to 4 ($n = 89$, 47.2%), > 4 to 8 ($n = 16$, 21.6%), > 8 ($n = 13$, 17.55%). After 1 year, three patients lost the follow-up. Among the remaining 132 patients, those with higher BSS had more mortality and morbidity, and the difference is statistically significant (MACE in ≥ 23 vs. < 23 , $p = 0.000755$); 10 patients in the ICR group had MACE compared with 1 patient in CR group (5.8% in CR group vs. 8.6% in ICR group, p -value of 0.38); however, the difference was not statistically significant. However, higher RSS acts as an indirect marker of increasing morbidity and mortality when compared within the tertiles, and the difference was statistically significant (RSS 1–4 group vs. > 4 MACE, $p = 0.0009559$, RSS < 8 vs. > 8 MACE, $p = 0.00000172$).

Conclusions This study proved that both BSS and higher RSS help to foretell the risk of adverse clinical outcomes in individuals with MVCAD who underwent PCI. RSS, which is an indirect marker of residual atherosclerosis, that is, ICR, had a positive correlation MACE after PCI.

Keywords

- ▶ residual SYNTAX Score (RSS)
- ▶ multivessel coronary artery disease (MVCAD)
- ▶ complete revascularization (CR)
- ▶ incomplete revascularization (ICR)



Introduction

In patients with multivessel coronary artery disease (MVCAD), residual SYNTAX (Synergy between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery) Score (RSS) has been shown to be a marker of the residual anatomic coronary atherosclerotic plaque burden and clinical comorbidity in patients undergoing revascularization (percutaneous or surgical) in a post-hoc analysis¹ of the SYNTAX trial.²⁻⁵ Incomplete revascularization (ICR) has been linked to the adverse clinical outcome on the short-term and long-term follow-up as shown by many studies.⁶⁻¹⁴ The theory of reasonable ICR has been proposed that is a clinical dictator of the acceptable burden of residual atherosclerotic plaque burden, post-revascularization in whom CR was could not need to be done.^{7,8,11,13,15} RSS is an objective and quantitative parameter, measures residual anatomic coronary atherosclerotic plaque burden and the complexity of coronary anatomy after the percutaneous coronary intervention (PCI).¹⁶ The objective of this study was to assess the application of RSS in prognostication in MVCAD patients at 1-year follow-up post-PCI.

Materials and Methods

After informed consent, a total of 135 patients were recruited retrospectively from our unit PCI registry. Those patients who were having MVCAD and underwent PCI were included. Exclusion criteria included subjects with prior coronary revascularization, and those subjects with a requirement of concomitant cardiac surgery (e.g., resection of aortic or left ventricular (LV) aneurysm, and valve surgery). We noted the demographic data (age, sex, socioeconomic status), risk factors (diabetic status hypertension, smoking), clinical presentation, laboratory parameters (electrocardiogram, echocardiogram, complete blood picture, liver function tests, serum electrolytes, renal function tests), and CAG findings in patients having MVCAD who underwent PCI. After coronary angiography, the severity of coronary atherosclerosis was assessed using the SYNTAX score. After PCI, the RSS was calculated to all the subjects. All the subjects with RSS of <0 were considered as CR group, and those with RSS >0 were considered as ICR group who were further classified to tertiles of RSS 0 to 4, 4 to 8, and >8. After 1 year, clinical outcomes were assessed.

Results

Among the total 135 patients, the mean age was 57.25 ± 17.55 , 76.3% were males, and 23.7% were females. Diabetes is observed in 89.4%, hypertension is observed in 88.6%, smoking is observed in 95.8%. Baseline SYNTAX Score (BSS) and RSS were calculated. The mean values of BSS and RSS were 20.2 ± 9.2 and 4.1 ± 7.0 , respectively. Based on RSS, the individuals were divided into two groups as follows: CR, 0 ($n = 17$, 23%); ICR, >0 to 4 ($n = 89$, 47.2%), >4 to 8 ($n = 16$, 21.6%), >8 ($n = 13$, 17.55%). After a follow-up of 1 year, three patients lost to follow-up. The distribution of clinical and angiographic profiles is shown in **Table 1**

The details are described in the following tables (**Tables 1–6**).

Among the remaining 132 patients, patients with higher BSS had more mortality and morbidity (major adverse cardiac and cerebrovascular events [MACE] in ≥ 23 vs. < 23 , $p = 0.000755$); 10 patients in the ICR group had MACE compared with one patient in CR group (5.8% in CR group vs. 8.6% in ICR group, p -value of 0.38) the difference of which was not statistically significant. Out of 135 patients, 75.5% (102) cases were men, and 24.5% (33) cases were women; MACE events were compared that showed p -value of 0.075, which is not significant. The occurrence of various risk factors predicting the occurrence of higher RSS like diabetes ($p = 0.14$), hypertension ($p = 0.22$), smoking ($p = 0.08$), LV dysfunction ($p = 0.17$), type of CAD ($p = 0.15$), and higher body mass index ($p = 0.12$) was not statistically significant. Presence of lesional calcification ($p = 0.49$) and presence of ostial disease ($p = 0.09$) are shown in **Table 1** **Figs. 1 to 7**.

Figs. 1 to 3 show the distribution of risk factors such as hypertension, diabetes, and smoking among the study population. There is no statistically significant difference observed in the distribution of risk factors among CR versus ICR group.

Figure 4 shows the distribution of echocardiographically observed LV dysfunction among the study population. There is no statistically significant difference observed in the distribution of LV dysfunction among CR versus ICR group.

Figure 5 shows the distribution of clinical presentations, such as acute coronary syndrome versus chronic stable angina among the study population. There is no statistically significant difference observed in the type of clinical presentation among CR versus ICR group.

Figs. 6 and 7 show the distribution of angiographic plaque characteristics such as lesional calcification and coronary ostial disease among the study population, which showed no statistically significant difference among CR versus ICR group.

The occurrence of MACE when compared within BSS < 23 versus BSS > 23 showed a statistically significant difference with a p -value of 0.0007558, as shown in **Table 2** **Fig. 8**.

Distribution of study population among post-PCI patients with RSS = 0 and RSS > 0, that is, CR versus ICR groups and the MACE in the individual group is shown in **Tables 3 and 4** **Figs. 9 and 10**, which show that higher number of MACE occurred in patients with high RSS; however, the difference was not statistically significant with a p -value of 0.38. The distribution of RSS across tertiles of the study population is described in **Fig. 9**.

Distribution of study population among different RSS groups and the MACE in the individual group is shown in **Tables 5 and 6**. These results showed that as the RSS is increasing, there is a higher chance for MACE, statistically significant difference observed when RSS 1 to 4 was compared with RSS > 4 p -values was 0.0009559, and RSS < 8 compared with > 8 p -values was 0.00000172.

Discussion

The present study showed that anatomical residual coronary artery disease is helping to predict MACE during follow-up of post-PCI patients. This is also shown in many trials such as

Table 1 Clinical and angiographic parameters

Parameter	Total (n = 135)	RSS = 0 (n = 17)	RSS > 0 (n = 118)	p-Value
Age	57.25 ± 17.55	55.69 ± 14.926	57.69 ± 17.7	0.61
Gender				
Male	102 (76%)	12 (70.5%)	90 (76.3%)	0.61
Female	33 (24%)	5 (29%)	28 (23.7%)	
Diabetes				
Yes	95 (72.4%)	10 (10.5%)	85 (89.4%)	0.14
No	40 (29.6%)	7 (17.5%)	33 (82.5%)	
Hypertension				
Yes	105 (77.7%)	12 (11.4%)	93 (88.6%)	0.22
No	30 (22.2%)	5 (16.6%)	25 (83.4%)	
Current smoking				
Yes	24 (17.7%)	1 (4.1%)	23 (95.8%)	0.08
No	111 (82.3%)	16 (14.4%)	95 (85.5%)	
LV function				
Good	98 (72.5%)	14 (14.2%)	84 (85.7%)	0.17
Mild dysfunction	18 (13.3%)	1 (5.5%)	17 (94.5%)	
Moderate dysfunction	11 (8.1%)	1 (9.09%)	10 (90.9%)	
Severe dysfunction	8 (5.9%)	1 (12.5%)	7 (98.75%)	
Type of CAD				
ACS	48 (35.5%)	8 (16.6%)	40 (83.3%)	0.15
CSA	87 (64.5%)	9 (10.3%)	78 (89.6%)	
BMI				
Normal	86 (63.7%)	13 (15.1%)	73 (84.9%)	0.12
Overweight	42 (31.1%)	4 (9.5%)	38 (90.5%)	
Obese	6 (4.4%)	0 (0%)	6 (100%)	
Underweight	1 (0.74%)	0 (0%)	1 (100%)	
Lesional calcification				
Yes	32 (23.8%)	4 (12.5%)	28 (87.5%)	0.49
No	103 (76.2%)	13 (12.6%)	90 (87.4%)	
Ostial disease				
Yes	12 (8.9%)	0 (0%)	12 (100%)	0.09
No	123 (91.1%)	17 (13.8%)	106 (86.2%)	
Predilatation				
Done	87 (64.5%)	12(13.8%)	75 (86.2%)	0.42
Not done	48 (38.5%)	6(12.5%)	42 (87.5%)	
Stent diameter	2.8 ± 0.7	2.9 ± 0.4	2.86 ± 0.26	
Stent length	22 ± 14.4	22 ± 15.4	21 ± 14.4	
GpIIb/IIIa inhibitor usage				
Yes	23 (17%)	4 (17.4%)	19 (82.6%)	0.22
No	112 (83%)	13 (11.6%)	99 (88.4%)	
BSS	20.2 ± 9.2	18.6 ± 7.3	20.47 ± 9.4	
RSS	4.1 ± 7.0	0	4.7 ± 6.8	

Abbreviations: BSS, Baseline SYNTAX Score; CAD, coronary artery disease; GpIIb/IIIa, glycoprotein IIb/IIIa inhibitors; LV, left ventricular; RSS, Residual SYNTAX Score.

Table 2 MACE events, according to BSS

Baseline SYNTAX score (BSS)	MACE+	MACE-	p-Value
<23 (n = 105)	3	102	
>23 (n = 30)	8	22	
	11	124	0.0007558

Abbreviations: BSS, Baseline SYNTAX Score; MACE, major adverse cardiac and cerebrovascular events.

Table 3 MACE according to RSS

Event	Total (n = 135)	RSS = 0	RSS > 0
Asymptomatic	121 (89.6%)	16 (13.2%)	105 (77.8%)
Angina	9 (6.6%)	1 (11.1%)	8 (88.9%)
Death	2 (1.5%)	0 (0%)	2 (100%)
No response	3 (2.2%)	0 (0%)	3 (100%)

Abbreviations: MACE, major adverse cardiac and cerebrovascular events; RSS, Residual SYNTAX Score.

Table 4 MACE as per different tertiles on ICR group

Responders (n = 132)	MACE+	MACE-	p-Value
CR, n = 17	1 (5.88%)	16 (94.1%)	0.49
ICR, n = 115	10 (8.6%)	105 (91.4%)	
	11	121	

Abbreviations: CR, complete revascularization; ICR, incomplete revascularization; MACE, major adverse cardiac and cerebrovascular events.

Table 5 Different types of MACE, according to RSS

RSS	n = 135	Angina	Death	Nonresponders	MACE no.
0	17	1	0	0	1
1-4	89	2	0	2	2
>4-8	16	1	0	0	1
>8	13	5	2	1	7
Total	135	9	2	3	11

Abbreviations: MACE, major adverse cardiac and cerebrovascular events; RSS, Residual SYNTAX Score.

Table 6 MACE in responder population

ICR	MACE+	MACE-	p-Value
n = 118 (3 are nonresponders)			
RSS1-4 (n = 89) (2 are nonresponders)	2	85	0.0008623
RSS 4-8 (n = 16)	1	15	0.00000097
RSS>8 (n = 13) (1 is nonresponders)	7	5	

Abbreviations: ICR, incomplete revascularization; MACE, major adverse cardiac and cerebrovascular events; RSS, Residual SYNTAX Score.

PRAMI (Preventive Angioplasty in Myocardial Infarction),¹⁷ CvLPRIT (Complete versus Lesion-Only Primary PCI Trial),¹⁸ and DANAMI-3 PRIMULTI¹⁹ the authors demonstrated that occurrence of MACE was a positively correlated with higher residual coronary artery disease that is objectively assessed using RSS.

In patients with MVCAD after undergoing PCI the residual plaque burden either obstructive or nonobstructive was associated with more adverse clinical outcomes and affecting the quality of life.^{20,21} Taking this into consideration, the RSS which is an objective measure of the residual plaque burden after PCI retains the value as a measure of the unaddressed anatomic coronary atherosclerotic disease burden that may declare future cardiovascular events.

Patients with elevated RSS were having more comorbidities and elderly compared with others; however, ICR is found to be an independent indicator of MACE during follow-up. Results of the present study have similarity with data published previously,^{6,22-24} suggesting that amount of anatomical residual atherosclerotic plaque burden, which is objectively reflected by a higher RSS > 8 after PCI, is associated with worse clinical outcomes in MVCAD patients who underwent PCI. This higher risk could be explained by the fact that patients with high RSS had a large extent of myocardium that is jeopardized or ischemic and overall vascular burden, which is high in these patients. In contrast, to the above findings, patients who had complete anatomical revascularization as evidenced by a lower RSS had the excellent prognosis at follow-up.^{10,18} Thus, decreasing the amount of residual plaque burden that reduces the ischemic burden to the patient would improve the overall long-term prognosis, as shown by many studies correlating survival benefit in patients with inducible ischemia who underwent revascularization.²⁵⁻²⁷

These results were challenging the interventional cardiologist while treating highly complex MVCAD in terms of addressing the entire coronary plaque burden.

Many compared the outcomes between CR versus ICR after PCI. A meta-analysis from nine studies by Aggarwal et al showed that less residual plaque burden following PCI was in line with a lower rate of death, myocardial infarction, and need for coronary artery bypass grafting at a mean follow-up of 29 months.²⁸ Another study by Head et al²⁹ investigated the impact of complete versus ICR on 3-year patient outcomes in the SYNTAX trial who declared that CR group had less number of MACE on follow-up. Consistent with the above studies, our study demonstrated that ICR occurred more frequently in patients with more complex coronary artery disease at baseline (total occlusions, more significant number of lesions), which occupied the highest tertile (>23) of the BSS.

Advances in PCI technology, with more easily deliverable newer generation drug-eluting Stents and newer adjunctive devices Systems which help in crossing of chronic total occlusions. Imaging technology like intravascular ultrasound, optical coherence tomography that provides guidance to interventional cardiologist to ensure stent optimization, helps in addressing the concept of ICR. Skilled and dedicated cardiologists who can tackle such complex coronary lesions and well-equipped hospital infrastructure help in ensuring full revascularization of

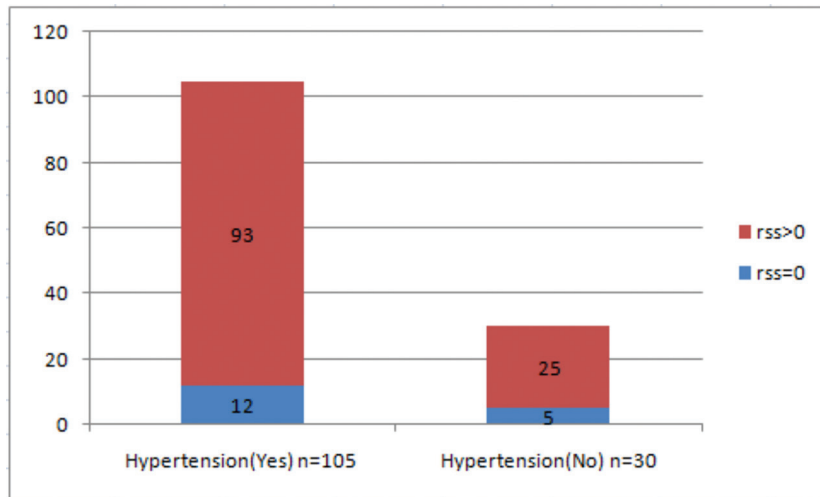


Fig. 1 Hypertension as a risk factor (CR vs. ICR group, p -value = 0.22). CR, complete revascularization; ICR, incomplete revascularization; RSS, residual SYNTAX Score.

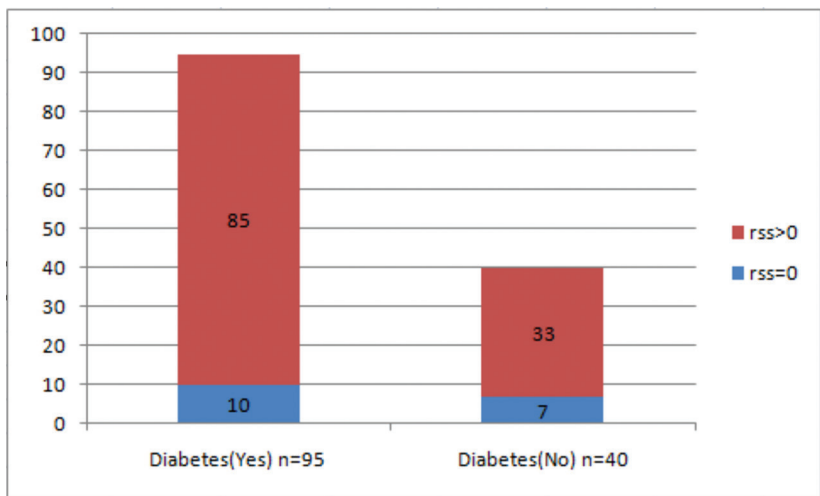


Fig. 2 Diabetes as a risk factor (CR vs. ICR group, p -value = 0.14). CR, complete revascularization; ICR, incomplete revascularization; RSS, residual SYNTAX Score.

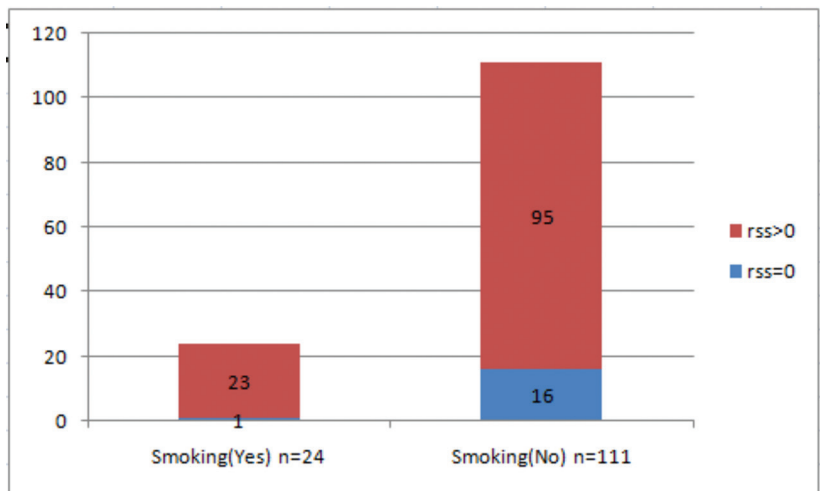


Fig. 3 Smoking as a risk factor (CR vs. ICR group, p -value = 0.08). CR, complete revascularization; ICR, incomplete revascularization; RSS, residual SYNTAX Score.

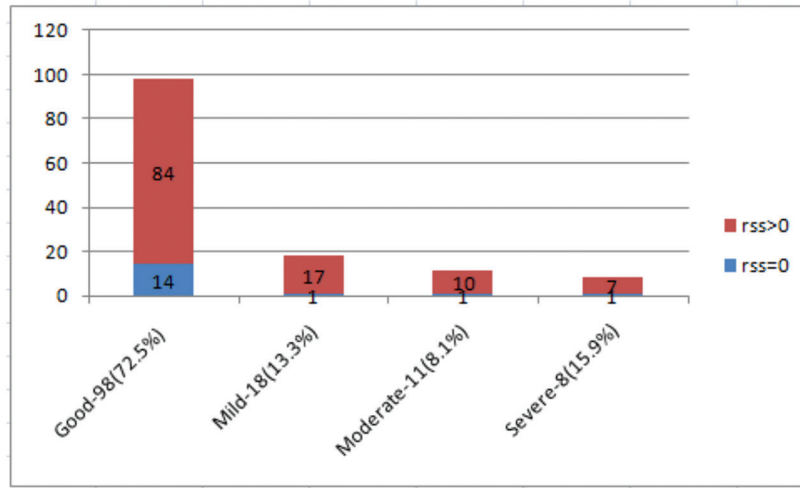


Fig. 4 Left ventricular dysfunction as a risk factor (CR vs. ICR group, p -value = 0.17). CR, complete revascularization; ICR, incomplete revascularization; RSS, residual SYNTAX Score.

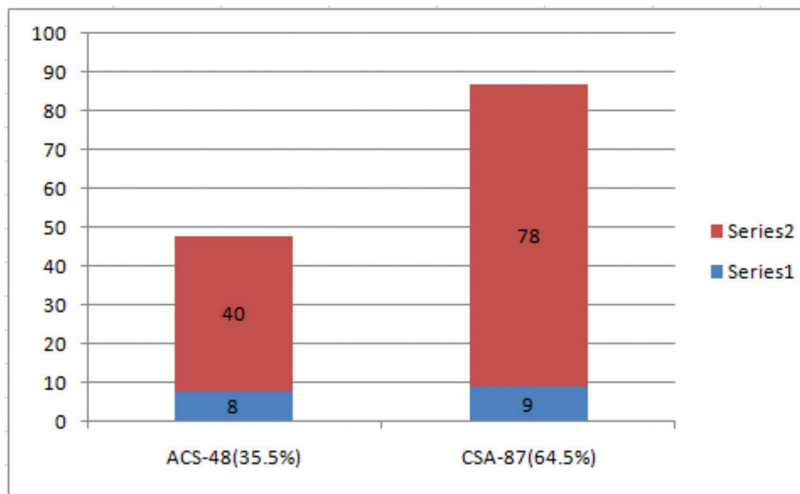


Fig. 5 Type of CAD as a risk factor (CR vs. ICR group, p -value = 0.15). ACS, CAD, coronary artery disease; CR, complete revascularization; CSA, ICR, incomplete revascularization; RSS, residual SYNTAX Score.

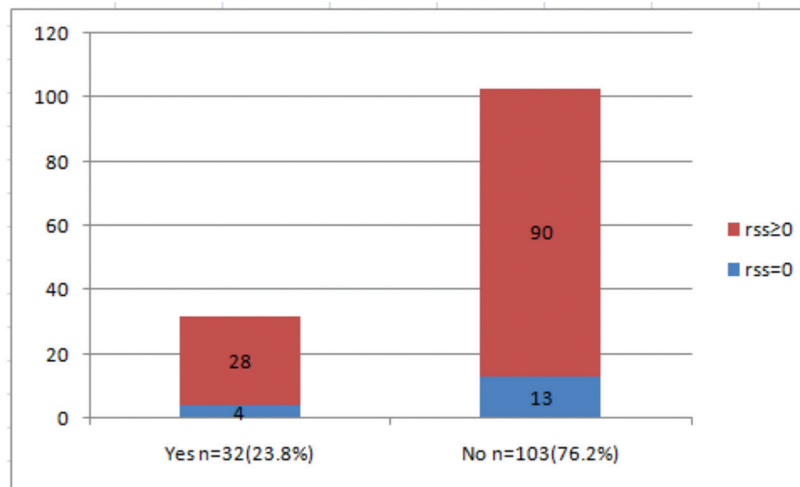


Fig. 6 Lesional calcification as a risk factor (CR vs. ICR group, p -value = 0.49). CR, complete revascularization; ICR, incomplete revascularization; RSS, residual SYNTAX Score.

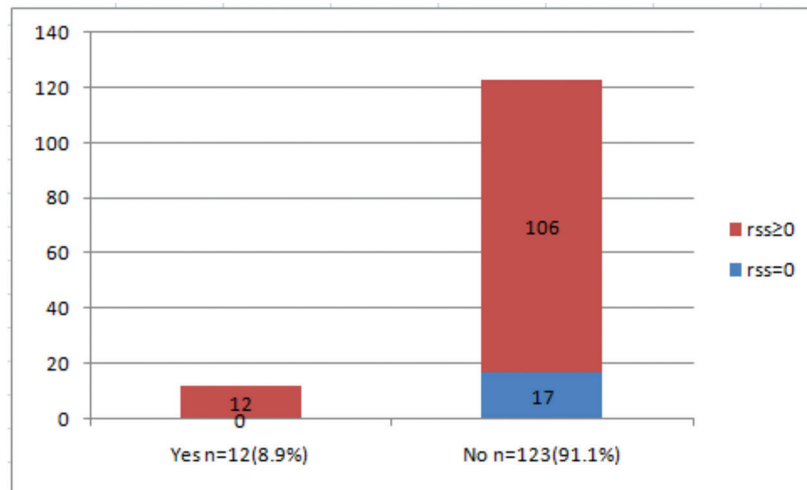


Fig. 7 Ostial disease as a risk factor (CR vs. ICR group, p -value = 0.09). CR, complete revascularization; ICR, incomplete revascularization; RSS, residual SYNTAX Score.

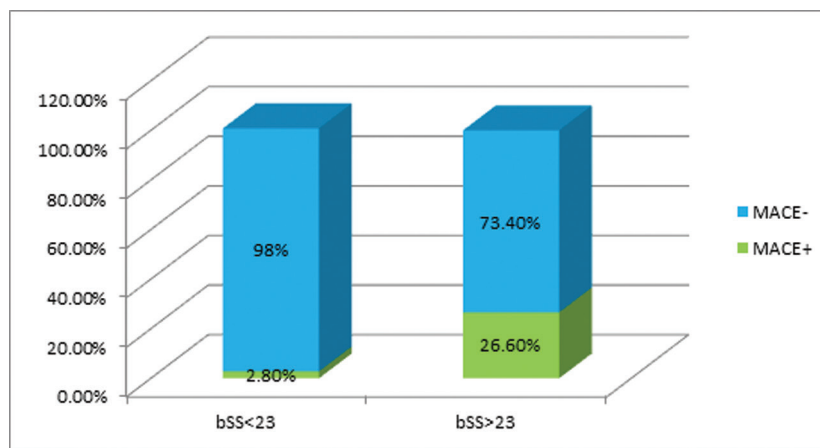


Fig. 8 Major adverse cardiac and cerebrovascular events (MACE) according to Baseline SYNTAX Score (BSS).

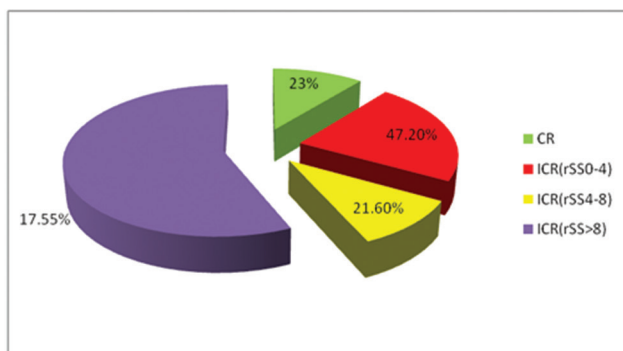


Fig. 9 Distribution of Residual SYNTAX Scores across tertiles. CR, complete revascularization; ICR, incomplete revascularization.

major epicardial vessels may directly improve long-term prognosis.³⁰⁻³⁴

The present study reconfirmed that a higher BSS was associated with higher RSS, which further is associated with more considerable morbidity and mortality. However, the RSS is based solely on angiographic quantification that cannot account for the interindividual variability related to the clinical risk factors, which are known and proven to

effect long-term outcomes after revascularization with PCI such as elderly age, presence of LV dysfunction, and associated renal dysfunction.³⁵

Thus, RSS added prognostic value in patients with MVCAD undergoing ICR, which supports its clinical use. We recommend that all patients with MVCAD undergoing PCI should undergo a functional assessment of the residual lesions even though they appear as anatomically significant that would translate into good clinical outcomes, which was proved in chronic kidney disease as well as obstructive sleep apnea patients also.³⁶

However, further studies are needed to assess the anatomic versus the functional residual burden of residual coronary atherosclerosis that further helps in prognostication.

Limitations

1. Calculation of RSS could be subjective. Thus, false positives and false negatives may occur.
2. Functional residual coronary atherosclerotic plaque burden, when compared with residual anatomical atherosclerotic plaque burden further, helps in prognostication, which could not be done in the present study.

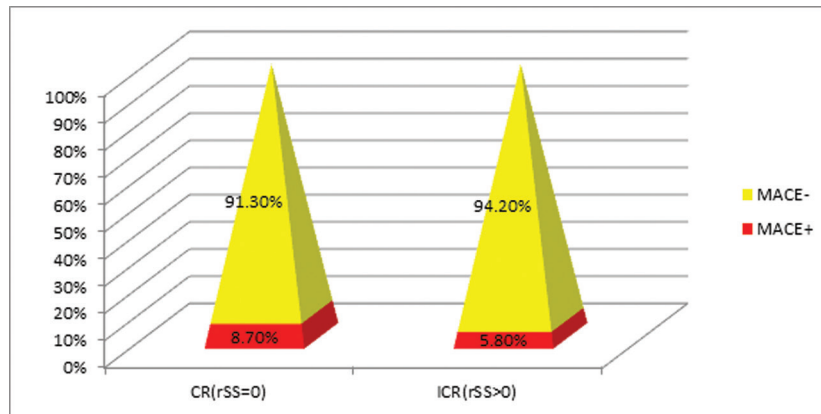


Fig. 10 Major adverse cardiac and cerebrovascular events (MACE) in complete revascularization (CR) versus incomplete revascularization (ICR) groups, p -value = 0.49. The difference is not statistically significant.

Conclusion

In conclusion, severe coronary atherosclerosis (SYNTAX ≥ 23 points) was significantly associated with an increased risk of morbidity and mortality; after PCI higher residual coronary atherosclerosis (SYNTAX ≥ 8 points) was associated with a higher risk of morbidity compared with SYNTAX < 8 points.

Conflicts of Interest

None declared.

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