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REVIEW

The Clinical Value of Syntax Scores in Predicting Coronary Artery Disease Outcomes

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Abstract

The Synergy Between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery (SYNTAX) score (SS) has significantly improved angiographic risk stratification. By analyzing angiographic variables, this score characterizes coronary artery disease qualitatively and quantitatively. To date, combining this score with other non-angiographic clinical scores has broadened perspectives regarding risk estimation, and future research on this topic appears promising.

Keywords: coronary artery disease; risk stratification; SS; risk estimation; non-angiographic clinical scores

Introduction

The Synergy Between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery (SYNTAX) score (SS) was created by the SYNTAX study to objectively assess the severity and scope of coronary artery disease (CAD) [1]. The ability of the SS to predict ischemia events after percutaneous coronary intervention (PCI) has been demonstrated in the SYNTAX trial and in other data [2–4]. Later, clinical applications of SS were developed [5, 6]. Increasing the number of clinical variables in the SS has been found to significantly influence risk classification [7, 8]. In this study, we aimed to provide information regarding the utility of SS and SS-derived scores in the assessment of CAD.

A PubMed search using the keywords "SS" and "coronary artery disease" yielded 1271 references spanning the years 2005 to 2021. The search was narrowed by removal of duplicate articles. The 202 articles remaining were scrutinized to ensure that they examined the SS and CAD. Articles that did not satisfy these criteria were rejected. This review focuses on the clinical and pathological connections between the SS and CAD. In Tables 1–3, we list the major themes of the references.

SYNTAX Score

Coronary arteries can be analyzed with quantitative factors. The American Heart Association's Arterial Revascularization Therapies Study (ARTS) has mapped coronary artery segment classification (openly accessible web-based score calculator: http://www.syntaxscore.com; Figure 1) [9]. Each coronary segment is identified by its left ventricular perfusion percentage and myocardial mass (Figure 2 from an openly accessible web-based score calculator: http://www.syntaxscore.com). Each serious lesion is visually evaluated and scored according to the American Heart Association's criteria. Table 4

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Table 1 Main Themes in References.

Reference no.	Authors	Number of patients	Patient condition	Main theme
Ref [2]	Serruys et al.	1800	Previously untreated three-vessel or LM CAD	CABG decreases severe adverse cardiac or cerebrovascular events, as compared with PCI.
Ref [3]	Capodanno et al.	255	LM CAD	The SXscore may predict cardiac mortality and MACE.
Ref [4]	Valgimigli et al.	306	Three-vessel disease	The SXscore may be used to predict prognosis in individuals with advanced CAD undergoing PCI.
Ref [5]	Head et al.	3075	Unsuitable for alternative treatment	Non-PCI patients have excellent surgical outcomes.
Ref [6]	Tomaszuk Kazberuk et al.	110	Dialysis	After PCI or CABG, the SS predicts mortality and MACEs.
Ref [7]	Farooq et al.	1800	CAD	SYNTAX II predicts CHD mortality over 4 years. SYNTAX II may aid in deciding between CABG and PCI.
Ref [8]	Palmerini et al.	2094	Non-ST-segment elevation acute coronary syndromes	These risk scores have the strongest predictive accuracy for ischemic end goals in patients with NSTEACS after PCI.
Ref [9]	Aktürk et al.	589	Non-ST-segment elevation acute coronary syndromes	MACE is predicted by TIMI and GRACE scores. SS-II might also predict in-hospital mortality, nonfatal MI, and stent thrombosis.
Ref [10]	Mohr et al.	1800	LM CAD or three-vessel disease	Low or intermediate SSs indicates less complicated disease (low or intermediate SSs indicates LM CAD).
Ref [11]	Farkouh et al.	1900	Diabetes and multivessel CAD	CABG outperforms PCI in terms of mortality and MI, but not stroke, in patients with diabetes and severe CAD.
Ref [12]	Park et al.	1146	LM CAD	People with unprotected LM CAD who had DES or CABG have different effects on long-term mortality depending on the degree of CAD complication.

Table 2 The Main Points of References.

Reference no.	Authors	Number of patients	Patient condition	Main theme
Ref [13]	Morice et al.	705	LM and/or three-vessel coronary disease	Extended follow-up is required for this challenging patient population to compare the two revascularization procedures' medium-term outcomes.
Ref [14]	Onuma et al.	148	Unprotected LM CAD	Late increase in patient-oriented composite end points necessitates LM CAD careful monitoring. SYNTAX and EuroSCORE scores may predict patient risk over time.
Ref [15]	Palmerini et al.	2627	Non-ST-segment elevation acute coronary syndromes	The SS predicts 1-year rates of mortality, cardiac death, MI, and TVR in patients with non-STEMİ undergoing PCI.
Ref [16]	Garg et al.	807	STEMI	A combination of SXscore and clinical parameters may improve risk classification in patients with STEMI receiving pPCI.
Ref [17]	Romagnoli et al.	1173	CAD	The EuroSCORE risk model correctly predicts early mortality after open-heart surgery. EuroSCORE may assist patients with CAD in choosing revascularization.
Ref [18]	Capodanno et al.	255	CAD	SS-based cardiac mortality prediction dramatically improves with EuroSCORE. Clinical and angiographic data are required to assess patient risk of LM PCI.
Ref [19]	Serruys et al.	701	Low-risk CAD	Compared with the SXscore, the global risk significantly improves the identification of low-risk individuals who might be treated safely and effectively with CABG or PCI.
Ref [20]	Ranucci et al.	4557	Elective cardiac surgery	Another advantage of the SXscore is its accuracy.

Table 3 The Main Points of References.

Reference no.	Authors	Number of patients	Patient condition	Main theme
Ref [21]	Garg et al.	512	CAD	The clinical SS predicts MACE and mortality by combining the SS with age, ejection fraction, and creatinine clearance.
Ref [22]	Girasis et al.	848	CAD	For drug-eluting stents, the SS and CSS stratify the risk of long-term clinical outcomes. CSS improves 5-year all-cause mortality forecasting.
Ref [23]	Farooq et al.	2627	Non-ST-segment elevation acute coronary syndromes	The core and extended models of the logistic clinical SS predict non-STEMI better than the anatomical SS alone. Its clinical use is validated by these results.
Ref [24]	Novara et al.	39	CAD	Using SS with FFR appears more appropriate in multivessel CAD. The F-SS reclassifies many patients, thus allowing for changes in treatment.
Ref [25]	Pijls et al.	1005	Multivessel CAD	Routine FFR testing in patients with multivessel CAD decreases mortality and MI at 2 years, as compared with angiography-guided PCI.
Ref [26]	Farooq et al.	903	CAD	The residual SS may help determine appropriate revascularization.
Ref [27]	Malkin et al.	240	CAD	The residual SS measures incomplete revascularization in patients with three-vessel disease receiving PCI. Only several patients achieved complete revascularization (rSYNTAX = 0), with minimal mortality.
Ref [28]	Farooq et al.	115	CAD	For patients with complex coronary disease undergoing surgical revascularization, the CABG SXscore may have long-term predictive value.

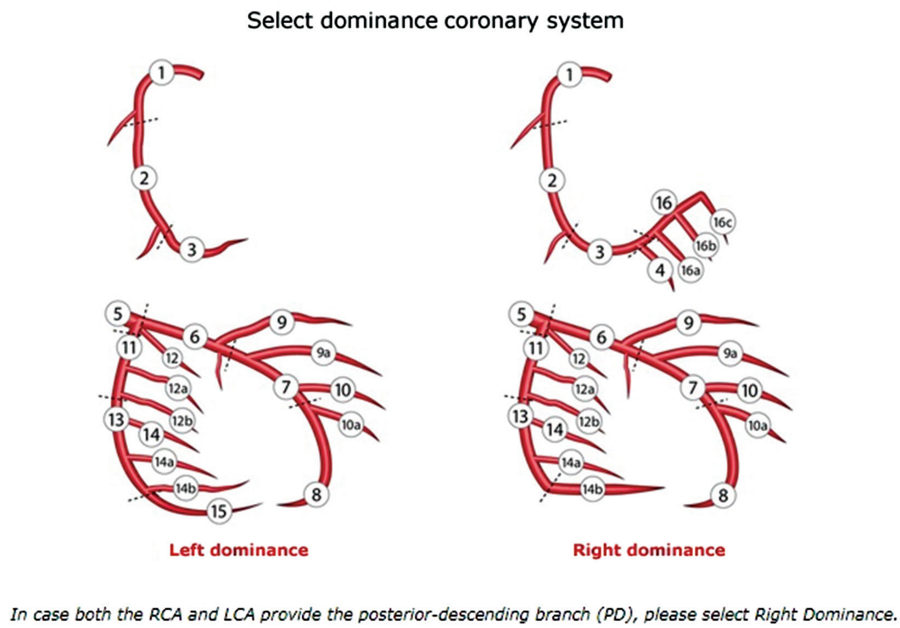
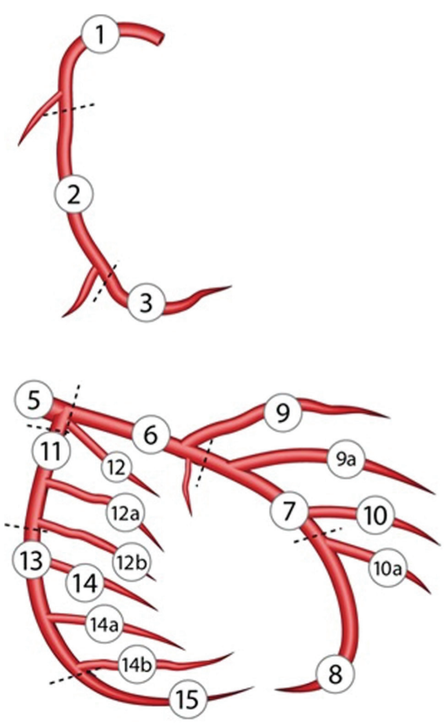


Figure 1 SYNTAX Score Developed by the American Heart Association with ARTS.



		Lesion:
	Segments:	
RCA	RCA proximal	1
	RCA mid	2
	RCA distal	3
LM	Left main	5
LAD	LAD proximal	6
	LAD mid	7
	LAD apical	8
	First diagonal	9
	Add. first diagonal	9a
	Second diagonal	10
	Add. second diagonal	10a
LCX	Proximal circumflex	11
	Intermediate/anterolateral	12
	Obtuse marginal	12a
	Obtuse marginal	12b
	Distal circumflex	13
	Left posterolateral	14
	Left posterolateral	14a
	Left posterolateral	14b
	Posterior descending	15

Figure 2 Specifying Lesion Segments.

displays the scoring based on several specific lesion features. The final score is divided into three categories: low, medium, and high (low: 0–22, medium: 23–32, and high: >32) [29].

The SYNTAX study (multivessel, left main [LM] vessel) involving 1800 patients was the first research to use SS [2]. After 1 year, the CABG group had fewer MACEs than the PCI group. While the 1-year MACE rates in SS tertiles treated with PCI gradually increased, the MACE rates in all SS tertiles treated with CABG remained similar. The recent SYNTAX study's 5-year results have revealed that patients who underwent CABG had a lower 1-year MACE rate than patients who underwent PCI [10].

Table 4 Specific Lesion Scoring in SS.

Aorto ostial stenosis	+1
Bifurcation, Medina classification	
Type 1-0-0, 0-1-0, 1-1-0	+1
Type 1-1-1, 0-0-1, 1-0-1, 0-1-1	+2
Angulation (<70)	+1
Trifurcation	
1/2/3/4 diseased segment	+3/+4/+5/+6
Diameter reduction	
Total occlusion	*5
Significant lesion, 50%–99%	*2
TO	
Age >3 months or unknown	+1
Blunt stump	+1
Bridging	+1
First segment visible beyond TO	+1/nonvisible segment
SB	
<1.5 mm or ≥1.5 mm	+1/+1
Severe tortuosity	+2
Length >20 mm	+1
Heavy calcification	+2
Thrombus	+1
Diffuse disease/small vessels	+1/segment

SB: side branch; SS: SYNTAX score; TO: total occlusion.

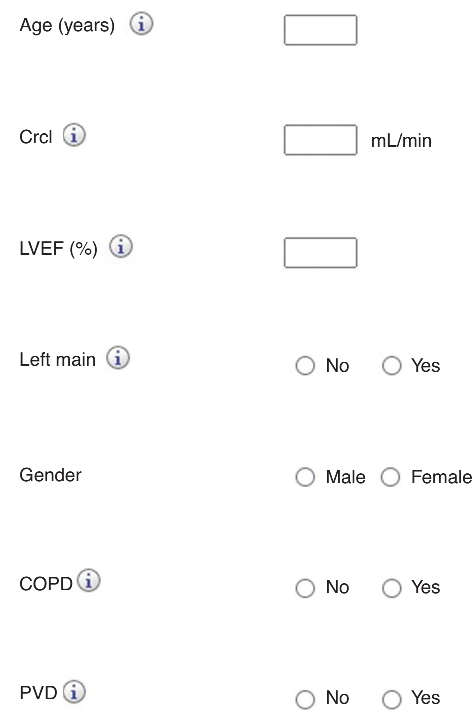


Figure 3 Integrating Clinical Variables into the SYNTAX Score (SYNTAX II).

However, data from the FREEDOM study, which included 1900 patients, has reported contradictory findings [11]. At 1 and 5 years of clinical follow-up, the MACE rates were the same in the CABG and PCI groups. The SYNTAX and FREEDOM studies had flaws in that patients were stratified with the same tertile threshold; consequently, the relationships between threshold values and outcomes are unclear.

In patients with unprotected LM CAD undergoing PCI, SS has significant prognostic value [12]. Tertiles with a high SS have higher rates of compound ischemic outcomes (death, MI, target lesion revascularization, or TVR) [13, 14]. SS has been found to be critical in determining the best revascularization strategy for patients with unprotected LM CAD [30].

The ACUITY study has found that SS had prognostic value in 2627 patients with non-ST-segment elevation MI (NSTEMI) who were treated with PCI. In that study, the upper tertile of SS was associated with more ischemic events than the lower second tertile, and predicted MACE at 1 year. This study has emphasized the prognostic value of SS in patients with acute coronary syndrome (ACS) and provided more detailed information on its prognostic value than the SYNTAX study [15]. The role of SS in the prognosis of ST-segment elevation MI (STEMI) has also been investigated. SS has been found to be a 1-year MACE predictor in patients with STEMI and to be associated with high tertile ischemic events [16]. A limiting factor in SS is the inability to score clinical variables. Comorbidities can have different short- and long-term outcomes in patients with similar scores [17]. To compensate for these limitations, clinical-based scores have been incorporated into the SS (openly accessible web-based score calculator: http://www.syntaxscore.com; Figure 3).

Clinically Based Risk Scores

Global Risk Classification

Global risk classification (GRC), a hybrid of the SS and EuroSCORE, improves SS's predictive ability. GRC has been found to predict cardiac mortality better than SS in multivessel disease and to improve net reclassification by 26% in patients with LM lesions undergoing PCI [18]. In a similar study, GRC has been found to be more predictive than SS or EuroSCORE alone in patients with LM or multivessel lesions [19].

Clinical SS

Clinical SS is SS in combination with a modified age, creatinine clearance, and ejection fraction (ACEF). With a combination of three clinical variables in patients with CABG, results with accuracy comparable to that of EuroSCORE have been obtained [20]. Clinical SS is calculated by adding the SS and modified ACEF scores. Clinical SS has been found to outperform SS alone or the modified ACEF score in predicting 5-year mortality and MACE [21]. Tertiary clinical SS increases mortality, MACE, and revascularization rates. Girasis et al. have also demonstrated that clinical SS is more valuable than SS alone in predicting mortality [22].

Logistic Clinical SS

Logistic clinical SS was created to address the limitations of SS and clinical SS. The multivariate logistic model did not produce SS or clinical SS, whereas the random ordering of the lesion site and complexity did. A score sheet based on logistic clinical SS variables has been created for individual risk assessment. Compared with the SS, this score has been found to be successful in predicting 1-year mortality but not MACE. Logistic clinical SS also has been demonstrated to provide accurate risk estimation in patients with ACS [23].

Functional SS

Fractional flow reserve (FFR) has been incorporated into the SS to distinguish between visual assessments, and it provides the benefit of causing fewer adverse ischemic events in complex lesions than angiography-guided PCI. In terms of interobserver reproducibility, functional SS outperforms SS. Functional SS is a potential tool for risk stratification and revascularization strategies, but it has been limited by a lack of prospective validation in complex lesions, its limited discriminatory power, and its time-consuming nature [24, 25].

Residual SS

Incomplete revascularization is a key cause of increased ischemic event risk after PCI in patients with high SS. The residual SS (rSS) has been improved to classify residual lesions after PCI. The calculation of RSS after PCI distinguishes it from SS. In ACS, RSS has been found to predict mortality and 1-year MACE. RSS has also been found to outperform baseline SS in terms of discrimination and predictive value for MACE. rSS, like basic SS, aids in the selection of a potential revascularization strategy by providing a uniform and standardized characterization of residual coronary lesions [26, 27].

CABG SS

Because SS was initially intended for native lesions, the CABG SS was created. This score is a combination of the basic SS calculation and scoring based on graft functionality. One limitation of this score is that the type of graft used is not included [28].

SS-II

SS-II was created to help physicians make better decisions regarding whether to perform CABG or PCI in complex coronary lesions. For long-term mortality prediction, SS-II, which integrates clinical variables with anatomical SS, provides a balance between CABG and PCI [31]. In patients with STEMI undergoing PCI, Girasis et al. [22] discovered that combining clinical variables with anatomical SS has a more accurate predictive value than only anatomical SS. Clinical SS outperforms anatomical SS in terms of 5-year all-cause mortality. SS-II has been found to predict in-hospital mortality and MACE in patients with STEMI and cardiogenic shock. SS-II is becoming increasingly important as a predictor of in-hospital outcomes in patients with STEMI.

SS-III

FFR derived from coronary CTA has been used to calculate a secondary endpoint including the physiological component (FFRCT). The anatomical lesion score (EQUALS Functional SS) is reduced when a lesion is not physiologically significant. The SS-III is determined by combining the functional SS with clinical features and comorbidities (Figure 4). The performance of recommended treatments when both CTA and conventional angiography are used has been found to reach 81%. FFRCT inclusion results in a change in treatment plans in approximately 16% of cases [33]. In the SYNTAX-III Revolution study, coronary CTA evaluation with FFRCT was feasible in 196 (87.9%) of 223 patients with multiple coronary lesions [32].

Recent Studies

Takahashi et al. have demonstrated that the newly developed SS-II 2020, which predicts 10-year mortality and 5-year MACE, may be useful in patients selected for CABG or PCI, thus allowing for the best revascularization strategy [34]. Hara et al. have observed that the logistic clinical SS outperforms the anatomical CABG SS in predicting 2-year mortality [35].

According to Modolo et al. [36], in the EXCEL study, SS-II overestimates 4-year mortality in patients with LM lesions. The modified SS can aid in the optimization of predilation, scaffold/stent sizing, and postdilation procedures [37]. According to Kawashima et al. [38], the prewiring updated logistic clinical SS is more accurate than the postwiring SS.

SS-II predicts major adverse events and cardiac death more successfully [39]. Kashiwagi et al. [40] have combined the rSS with clinical factors to produce a combined score. This composite score is computed with the SS-II calculator, with rSS rather than SS. The combined score may help predict long-term mortality after PCI.

Lee et al. [41] have observed a strong relationship between increased exercise capacity after PCI and an integrated anatomical and functional scoring system (residual functional SS). According to Shabbir et al. [42], a calculated coronary artery

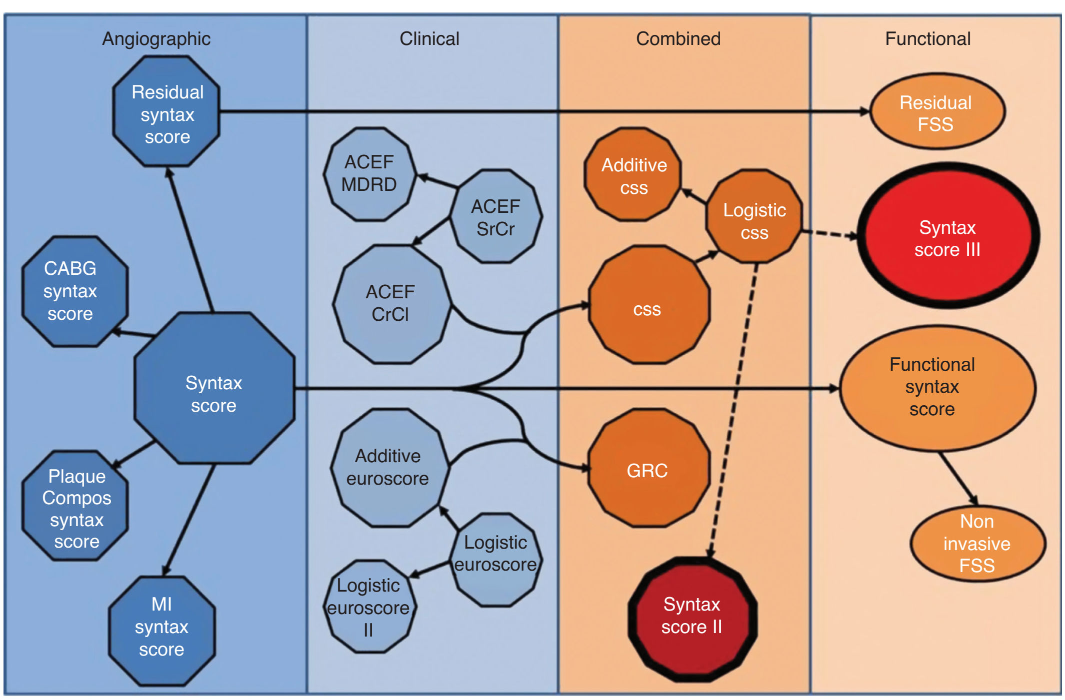


Figure 4 Adapted with Permission from Modolo et al. [32].
The pathway to SYNTAX III. ACEF, age, creatinine, ejection fraction; CABG, coronary artery bypass grafting; Compos, compositional; CrCl, creatinine clearance; CSS, clinical SYNTAX score; FSS, functional SYNTAX score; GRC, global risk classification; MI, myocardial infarction; MDRD, Modification of Diet in Renal Disease; SrCr, serum creatinine; SYNTAX, Synergy between PCI with Taxus and Cardiac Surgery

calcium score greater than 212 may be associated with SS. Matos et al. [43] have demonstrated that the Gensini score and thrombus burden improve the predictive value of SS in the detection of no-reflow.

Wang et al. [44], in contrast, have found that the atherogenic index of plasma is associated with the SS and may help prevent CAD in the Chinese population. According to Kahraman et al. [45], a high neutrophil/lymphocyte ratio is an independent predictor of elevated rSS in patients with STEMI. Basman et al. [46] have observed significant inter- and intra-user variability in the calculation of SS. Therefore, they view the use of SS in the revascularization strategy with skepticism.

According to Erdogan et al. [47], the fibrinogen-albumin ratio may be useful in predicting moderate-to-high SS in patients with NSTEMI. Low endothelial progenitor cell count or activity, as well as attenuated nitric oxide synthase, have been associated with poor endothelial function in patients with high SS. These findings suggest that novel surrogate markers for SS in CAD severity prediction might be developed [48].

Advantages of CABG vs. PCI

PCI and CABG are the two basic revascularization procedures used in patients with LM or multivessel CAD [49]. Recent research has suggested that CABG may be more advantageous and efficacious in individuals with diabetes mellitus and multivessel CAD [50]. PCI is a favorable alternative for patients with a low SS, but CABG is indicated for those with a high SS [29]. Another study linked PCI to poorer clinical outcomes in patients with high SS [51]. The ARTS II registry has also found that PCI revascularization is associated with poorer clinical results among patients with higher SS, thus demonstrating the advantages of CABG in these individuals [52]. However, whereas the SS has cut-off values of 16 and 24, the cut-off value in that study was 33. Similarly, a retrospective study has found that patients who had CABG recommended on the basis of a high SS but refused and chose PCI have an elevated risk of cardiac adverse events. [53] Even when the clinical SS is used to predict the best treatment approach, if patients with a high score refuse CABG in favor of PCI, subsequent outcomes have been found to be poorer.

Conclusions

More scientific research is needed to determine the cutoff value of the SS for risk stratification in various clinical situations. The SS-II and FFRCT risk scores have resulted in significant advances in risk stratification and thus are promising for future use.

Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this work. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; and in the decision to publish the results.

REFERENCES

1. Sianos G, Morel MA, Kappetein AP, Morice MC, Colombo A, Dawkins K, et al. The SYNTAX score: an angiographic tool grading the complexity of coronary artery disease. EuroIntervention 2005;1:219–27.
2. Serruys PW, Morice MC, Kappetein AP, Colombo A, Holmes DR, Mack MJ, et al. Percutaneous coronary intervention versus coronary artery bypass grafting for severe coronary artery disease. N Engl J Med 2009;360:961–72.
3. Capodanno D, Di Salvo ME, Cincotta G, Miano M, Tamburino C, Tamburino C. Usefulness of the SYNTAX score for predicting clinical outcome after percutaneous coronary intervention of unprotected left main coronary artery disease. Circ Cardiovasc Interv 2009;2:302–8.
4. Valgimigli M, Serruys PW, Tsuchida K, Vaina S, Morel MA, van den Brand MJ, et al. Cyphering the complexity of coronary artery disease using the SYNTAX score to predict clinical outcome in patients with three vessel lumen obstruction undergoing percutaneous coronary intervention. Am J Cardiol 2007;99:1072–81.
5. Head SJ, Holmes DR Jr., Mack MJ, Serruys PW, Mohr FW, Morice MC, et al. Risk profile and 3-year outcomes from the SYNTAX

percutaneous coronary intervention and coronary artery bypass grafting nested registries. J Am Coll Cardiol Intv 2012;5:618–25.
6. Tomaszuk-Kazberuk A, Kozuch M, Malyszko J, Bachorzewska-Gajewska H, Kobus G, Dobrzycki S, et al. Angiographically derived SYNTAX score and its prognostic value in dialysis patients: comparison with the Khan index. Can J Cardiol 2012;28:450–7.
7. Farooq V, van Klaveren D, Steyerberg EW, Meliga E, Vergouwe Y, Chieffo A, et al. Anatomical and clinical characteristics to guide decision making between coronary artery bypass surgery and percutaneous coronary intervention for individual patients: development and validation of SYNTAX score II. Lancet 2013;381:639–50.
8. Palmerini T, Caixeta A, Genereux P, Cristea E, Lansky A, Mehran R, et al. Comparison of clinical and angiographic prognostic risk scores in patients with acute coronary syndromes: analysis from the Acute Catheterization and Urgent Intervention Triage StrategY (ACUITY) trial. Am Heart J 2012;163:383–91, 391.e1–5.
9. Aktürk E, Aşkın L, Taşolar H, Türkmen S, Kaya H. Comparison of the predictive roles of risk scores of in-hospital major adverse cardiovascular events in patients with non-st elevation myocardial infarction undergoing percutaneous coronary intervention. Med Princ Pract 2018;27:459–65.
10. Mohr FW, Morice MC, Kappetein AP, Feldman TE, Ståhle E, Colombo A, et al. 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;381:629–38.
11. Farkouh ME, Domanski M, Sleeper LA, Siami FS, Dangas G, Mack M, et al. Strategies for multivessel revascularization in patients with diabetes. N Engl J Med 2012;367:2375–84.
12. Park DW, Kim YH, Yun SC, Song HG, Ahn JM, Oh JH, et al. Complexity of atherosclerotic coronary artery disease and long-term outcomes in patients with unprotected left main disease treated with drug-eluting stents or coronary artery bypass grafting. J Am Coll Cardiol 2011;57:2152–9.
13. Morice MC, Serruys PW, Kappetein AP, Feldman TE, Ståhle E, Colombo A, et al. Outcomes in patients with de novo left main disease treated with either percutaneous coronary intervention using paclitaxel-eluting stents or coronary artery bypass graft treatment in the Synergy Between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery (SYNTAX) trial. Circulation 2010;121:2645–53.
14. Onuma Y, Girasis C, Piazza N, e Garcia-Garcia HM, Kukreja N, Garg S, et al. Long-term clinical results following stenting of the left main stem: insights from RESEARCH (Rapamycin-Eluting Stent Evaluated at Rotterdam Cardiology Hospital) and T-SEARCH (Taxus-Stent Evaluated at Rotterdam Cardiology Hospital) Registries. J Am Coll Cardiol Intv 2010;3:584–94.
15. Palmerini T, Genereux P, Caixeta A, Cristea E, Lansky A, Mehran R, et al. Prognostic value of the SYNTAX score in patients with acute coronary syndromes undergoing percutaneous coronary intervention: analysis from the ACUITY (Acute Catheterization and Urgent Intervention Triage StrategY) trial. J Am Coll Cardiol 2011;57:2389–97.
16. Garg S, Sarno G, Serruys PW, Rodriguez AE, Bolognese L, Anselmi M, et al. Prediction of 1-year clinical outcomes using the SYNTAX score in patients with acute ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention: a substudy of the STRATEGY (Single High Dose Bolus Tirofiban and Sirolimus-Eluting Stent Versus Abciximab and Bare-Metal Stent in Acute Myocardial Infarction) and MULTI-STRATEGY (Multicenter Evaluation of Single High-Dose Bolus Tirofiban Versus Abciximab With Sirolimus-Eluting Stent or Bare Metal Stent in Acute Myocardial Infarction Study) trials. J Am Coll Cardiol Intv 2011;4:66–75.
17. Romagnoli E, Burzotta F, Trani C, Siviglia M, Biondi-Zoccai GG, Niccoli G, et al. EuroSCORE as predictor of in-hospital mortality after percutaneous coronary intervention. Heart 2009;95:43–8.
18. Capodanno D, Miano M, Cincotta G, Aggegi A, Ruperto C, Bucalo R, et al. EuroSCORE refines the predictive ability of SYNTAX score in patients undergoing left main percutaneous coronary intervention. Am Heart J 2010;159:103–9.
19. Serruys PW, Farooq V, Vranckx P, Girasis C, Brugaletta S, Garcia-Garcia HM, et al. A global risk approach to identify patients with left main or 3-vessel disease who could safely and efficaciously be treated with percutaneous coronary intervention: the SYNTAX Trial at 3 years. J Am Coll Cardiol Intv 2012;5:606–17.
20. Ranucci M, Castelvecchio S, Menicanti L, Frigiola A, Pelissero G. Risk of assessing mortality risk in elective cardiac operations: age, creatinine, ejection fraction, and the law of parsimony. Circulation 2009;119:3053–61.
21. Garg S, Sarno G, Garcia-Garcia HM, Girasis C, Wykrzykowska J, Dawkins KD, et al. A new tool for the risk stratification of patients with complex coronary artery disease: the clinical SYNTAX score. Circ Cardiovasc Interv 2010;3:317–26.
22. Girasis C, Garg S, Räber L, Sarno G, Morel MA, Garcia-Garcia HM, et al. SYNTAX score and clinical SYNTAX score as predictors of very long-term clinical outcomes in patients undergoing percutaneous coronary interventions: a substudy of SIRolimus-eluting stent compared with pacliTAXel-eluting stent for coronary revascularization (SIRTAX) trial. Eur Heart J 2011;32:3115–27.
23. Farooq V, Vergouwe Y, Généreux P, Bourantas CV, Palmerini T, Caixeta

A, et al. Prediction of 1-year mortality in patients with acute coronary syndromes undergoing percutaneous coronary intervention: validation of the logistic clinical syntax (synergy between percutaneous coronary interventions with taxus and cardiac surgery) score. J Am Coll Cardiol Intv 2013;6:737–45.
24. Novara M, D'Ascenzo F, Gonella A, Bollati M, Biondi-Zoccai G, Moretti C, et al. Changing of SYNTAX score performing fractional flow reserve in multivessel coronary artery disease. J Cardiovasc Med (Hagerstown) 2012;13:368–75.
25. Tonino PAM, De Bruyne B, Pijls NJH, Siebert U, Ikeno F, van't Veer M, et al. Fractional flow reserve versus angiography for guiding percutaneous coronary intervention in patients with multivessel coronary artery disease: 2-year follow-up of the FAME (Fractional Flow Reserve Versus Angiography for Multivessel Evaluation) study. J Am Coll Cardiol 2010;56:177–84.
26. Farooq V, Serruys PW, Bourantas CV, Zhang Y, Muramatsu T, Feldman T, et al. 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: clinical perspective. Circulation 2013;128:141–51.
27. Malkin CJ, George V, Ghobrial MS, Krishnan A, Siotia A, Raina T, et al. Residual SYNTAX score after PCI for triple vessel coronary artery disease: quantifying the adverse effect of incomplete revascularisation. EuroIntervention 2013;8:1286–95.
28. Farooq V, Girasis C, Magro M, Onuma Y, Morel MA, Heo JH, et al. The CABG SYNTAX Scoredan 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;8:1277–85.
29. Yadav M, Palmerini T, Caixeta A, Madhavan MV, Sanidas E, Kirtane AJ, et al. Prediction of coronary risk by SYNTAX and derived scores: synergy between percutaneous coronary intervention with taxus and cardiac surgery. J Am Coll Cardiol 2013;62:1219–30.
30. Hillis LD, Smith PK, Anderson JL, Bittl JA, Bridges CR, Byrne JG, et al. 2011 ACCF/AHA guideline for coronary artery bypass graft surgery: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol 2011;58:e123–210.
31. Aşkın L, Aktürk E. Association between SYNTAX II score and electrocardiographic evidence of no-reflow in patients with ST-segment elevation myocardial infarction. Turk Kardiyol Dern Ars 2018;46:455–63.
32. Andreini D, Modolo R, Katagiri Y, Mushtaq S, Sonck J, Collet C, et al. Impact of fractional flow reserve derived from coronary computed tomography angiography on heart team treatment decision-making in patients with multivessel coronary artery disease: insights from the SYNTAX III REVOLUTION trial. Circ Cardiovasc Interv 2019;12:e007607.
33. Modolo R, Collet C, Onuma Y, Serrus PW. SYNTAX II and SYNTAX III trials: what is the take home message for surgeons? Ann Cardiothorac Surg 2018;7:470–82.
34. Takahashi K, Serruys PW, Fuster V, Farkouh ME, Spertus JA, Cohen DJ, et al. SYNTAXES, FREEDOM, BEST, and PRECOMBAT trial investigators. Redevelopment and validation of the SYNTAX score II to individualise decision making between percutaneous and surgical revascularisation in patients with complex coronary artery disease: secondary analysis of the multicentre randomised controlled SYNTAXES trial with external cohort validation. Lancet 2020;396:1399–412.
35. Hara H, Kogame N, Takahashi K, Modolo R, Chichareon P, Tomaniak M, et al. Usefulness of the updated logistic clinical SYNTAX score after percutaneous coronary intervention in patients with prior coronary artery bypass graft surgery: Insights from the GLOBAL LEADERS trial. Catheter Cardiovasc Interv 2020;96:E516–E26.
36. Modolo R, Chichareon P, van Klaveren D, Dressler O, Zhang Y, Sabik JF, et al. Impact of non-respect of SYNTAX score II recommendation for surgery in patients with left main coronary artery disease treated by percutaneous coronary intervention: an EXCEL substudy. Eur J Cardiothorac Surg 2020;57:676–83.
37. Zhao X, Guan C, Yuan J, Xie L, Wang H, Hou S, et al. A modified predilation, sizing, and postdilation scoring system for patients undergoing metallic drug-eluting stent implantations. Catheter Cardiovasc Interv 2020;95 Suppl 1:558–64.
38. Kawashima H, Hara H, Wang R, Ono M, Gao C, Takahashi K, et al. Usefulness of updated logistic clinical SYNTAX score based on MI-SYNTAX score in patients with ST-elevation myocardial infarction. Catheter Cardiovasc Interv 2021;97:E919–E28.
39. Yanes Bowden GJ, Bosa Ojeda F, Jiménez Sosa A, Sánchez-Grande Flecha A, Méndez Vargas C, Leiva Gordillo M, et al. Prognostic value of SYNTAX score and SYNTAX score II in an 'all-comers' population treated with angoplasty. Coron Artery Dis 2021;32:231–40.
40. Kashiwagi D, Ebisawa S, Yui H, Maruyama S, Nagae A, Sakai T, et al. Prognostic usefulness of residual SYNTAX score combined with clinical factors for patients with acute coronary syndrome who underwent percutaneous coronary intervention from the SHINANO Registry. Heart Vessels 2021;36:170–9.
41. Lee SH, Choi KH, Lee JM, Shin D, Hwang D, Kim HK, et al. Residual functional SYNTAX score by quantitative flow ratio and improvement of exercise capacity after revascularization. Catheter Cardiovasc Interv 2021;97:E454–66.
42. Shabbir A, Virk ST, Malik J, Kausar S, Nazir TB, Javed A. Coronary Artery Calcium Score: Assessment of SYNTAX Score and Prediction

of Coronary Artery Disease Cureus 2021;13:e12704.
43. Matos LCV, Carvalho LS, Modolo R, Santos S, Silva JCQE, Almeida OLR, et al. Gensini score and thrombus burden add predictive value to the SYNTAX score in detecting no-reflow after myocardial infarction. Arq Bras Cardiol 2021;116:466–72.
44. Wang L, Chen F, Xiaoqi C, Yujun C, Zijie L. Atherogenic index of plasma is an independent risk factor for coronary artery disease and a higher SYNTAX score. Angiology 2021;72:181–6.
45. Kahraman S, Agus HZ, Avci Y, Serbest NG, Guner A, Erturk M. The Neutrophil to Lymphocyte Ratio (NLR) is associated with residual syntax score in patients with st-segment elevation myocardial infarction. Angiology 2021;72:166–73.
46. Basman C, Levine E, Tejpal A, Thampi S, Rashid U, Barry R, et al. Variability and reproducibility of the SYNTAX score for triple-vessel disease. Cardiovasc Revasc Med 2021:S1553-8389(21)00452-8.
47. Erdoğan G, Arslan U, Yenercağ M, Durmuş G, Tuğrul S, Şahin İ. Relationship between the fibrinogen-to-albumin ratio and SYNTAX score in patients with non-st-elevation myocardial infarction. Rev Invest Clin 2021. doi: 10.24875/RIC.20000534. Epub ahead of print.
48. Zhang B, Li D, Liu G, Tan W, Zhang G, Liao J. Impaired activity of circulating EPCs and endothelial function are associated with increased Syntax score in patients with coronary artery disease. Mol Med Rep 2021;23:321.
49. Bundhun PK, Pursun M, Teeluck AR, Bhurtu A, Soogund MZ, Huang WQ. Adverse cardiovascular outcomes associated with coronary artery bypass surgery and percutaneous coronary intervention with everolimus eluting stents: a metaanalysis. Sci Rep 2016;6:35869.
50. Bundhun PK, Wu ZJ, Chen MH. Coronary artery bypass surgery compared with percutaneous coronary interventions in patients with insulin-treated type 2 diabetes mellitus: a systematic review and metaanalysis of 6 randomized controlled trials. Cardiovasc Diabetol 2016;15:2.
51. Kim YH, Park DW, Kim WJ, Lee JY, Yun SC, Kang SJ, et al. Validation of SYNTAX (Synergy between PCI with Taxus and Cardiac Surgery) score for prediction of outcomes after unprotected left main coronary revascularization. JACC Cardiovasc Interv 2010;3:612–23.
52. Serruys PW, Onuma Y, Garg S, Vranckx P, De Bruyne B, Morice MC, et al. ARTS II Investigators 5-year clinical outcomes of the ARTS II (Arterial Revascularization Therapies Study II) of the sirolimus-eluting stent in the treatment of patients with multivessel de novo coronary artery lesions. J Am Coll Cardiol 2010;55:1093–101.
53. Witberg G, Lavi I, Gonen O, Assali A, Vaknin-Assa H, Lev E, et al. Long-term outcomes of patients with complex coronary artery disease according to agreement between the SYNTAX score and revascularization procedure in contemporary practice. Coron Artery Dis 2014;25:296–303.