



Original Article

The SYNTAX Revascularization Index and major cardiovascular events in patients with multivessel coronary artery disease in the Instituto Nacional de Cardiología Ignacio Chávez – Mexico

Tania Vásquez Loarte^{1,a}, Yigal Piña Reyna^{2,b}, Marco Peña Duque^{2,b}, César Antonio Ortiz Zegarra^{3,c}

ABSTRACT

Received: 12 november 2022
Accepted: 29 march 2023
Online: 31 march 2023

Authors' affiliation

¹ Universidad de San Martín de Porras, Lima, Peru.² Instituto Nacional de Cardiología "Ignacio Chávez", Mexico City, Mexico.³ Instituto Nacional Cardiovascular INCOR, EsSalud, Lima, Peru.^a Epidemiologist^b Cardiologist^c Physician of the Interventional Cardiology Service

Correspondence

César Ortiz Zegarra
Jr. 24 número 102, Dpto. 101. Urb. Mariscal Ramón Castilla. 15037, Lima, Perú.
+51 993478726.

Mail

cesarortizzegarra@hotmail.com

Funding

Self-financed

Conflicts of Interest

The authors declare no conflict of interest

Cite as:

Vásquez Loarte T, Piña Reyna Y, Peña Duque M, Ortiz Zegarra CA. The SYNTAX Revascularization Index and major cardiovascular events in patients with multivessel coronary artery disease in the Instituto Nacional de Cardiología Ignacio Chávez – Mexico. Arch Peru Cardiol Cir Cardiovasc. 2023;4(1):7-12. doi: 10.47487/apcyccv.v4i1.282.



This work is licensed under a Creative Commons Attribution 4.0 International License

Objective. To evaluate the degree of incomplete revascularization in patients with multiarterial coronary artery disease who underwent percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) using the Syntax revascularization index (SRI) and its relationship to major cardiovascular events during follow-up. **Materials and methods.** Observational, retrospective study with 4-year follow-up of patients with multiarterial coronary artery disease who underwent surgical or percutaneous coronary revascularization, in whom the baseline Syntax score (bSS) and the residual Syntax score (rSS) were calculated. The Syntax Revascularization Index (SRI) was determined with the following formula: $SRI = (1 - [rSS/bSS]) \times 100$, and major cardiovascular events at 4-year follow-up were compared. **Results.** Two hundred patients (100 in each group) were evaluated. Mean rSS in group 1 was 83.2%, and in group 2, 79.0% ($p=0.88$). Mean complete revascularization was 41% in the first group and 35% in the second. A cutoff point $\leq 90\%$ of SRI had the best accuracy for predicting major cardiovascular events (area under the curve of 0.60; 95% confidence interval [CI]: 0.49-0.71, $p<0.05$). In multivariate analysis IRS was an independent predictor of major cardiovascular events (Hazard Ratio [HR]: 2.6; 95%CI: 1.32-3.22, $p=0.043$). **Conclusions.** The SRI may be useful for measuring the degree of revascularization in patients with multiarterial coronary artery disease treated percutaneously or surgically. An SRI $\geq 90\%$ may be an acceptable target for revascularization.

Keywords: Myocardial Revascularization; Percutaneous Coronary Intervention; Coronary Artery Bypass; Coronary Disease (source: MeSH-NLM).

Introduction

In the management of multiarterial coronary artery disease, whether by coronary artery bypass grafting (CABG) or percutaneous coronary intervention (PCI) with stents, it is important to achieve complete revascularization⁽¹⁾, which consists of successfully treating all vessels with severe disease. However, this is not achieved in a significant proportion of cases (at least 40% of interventions)⁽²⁻⁶⁾

and can be associated with increased mortality and morbidity in the short- or long-term⁽⁶⁻¹³⁾. The incomplete revascularization causes are the presence of chronic total occlusions, diffuse lesions and bad distal nail-beds, among others⁽¹³⁻¹⁵⁾. Reasonable incomplete revascularization^(8,9) is defined as incomplete revascularization that does not imply a greater mortality or morbidity in this patient's group in long-term. For this purpose, an index has been developed, subsequently applied to percutaneous intervention or revascularization surgery in untreated lesions, called the

residual SYNTAX score (rSS) ^(3,4,16-18), which suggests that a value greater than 8 of this score is associated with greater mortality at 1-year follow-up. However, this index measures an absolute value and does not reflect the degree of revascularization achieved in each patient. Therefore, the SYNTAX revascularization index (SRI) is proposed, which determines a relationship between the residual SS and the baseline score expressed as a percentage for these patients, which has already been applied in previous studies with acceptable results ⁽¹⁵⁾.

The aim of the present study was to determine the degree of revascularization in patients treated percutaneously or surgically using the SRI and to evaluate its impact on major cardiovascular events (MACE).

Materials and Methods

Design and study population

Observational, retrospective, 4-year follow-up study of patients with multiarterial coronary artery disease diagnosed by invasive coronary angiography who underwent surgical or percutaneous revascularization between 2010 and 2011 at the Instituto Nacional de Cardiología Ignacio Chávez in Mexico City, Mexico. Convenience sampling was performed until the sample size of 200 patients was reached (100 patients who underwent surgical revascularization and 100 patients who underwent percutaneous revascularization).

Inclusion criteria were male and female patients aged 18 years or older with documented stable coronary artery disease who underwent percutaneous or surgical coronary revascularization. Patients with available coronary angiographic images and adequate clinical follow-up. Exclusion criteria were patients with incomplete data or follow-up, patients with stage IV or higher renal failure, and patients with acute coronary ischemic syndrome on admission.

Variables

Among the variables studied, multiarterial coronary artery disease was defined as coronary artery disease with stenosis at least 50%, defined angiographically in two or more epicardial vessels (or in their main branches). The baseline SYNTAX score (bSS) is a scale that assesses the coronary artery disease complexity according to the anatomical characteristics of each diseased segment. The rSS is a scale that quantifies the degree and complexity of residual coronary artery disease after percutaneous coronary intervention or revascularization surgery.

Complete revascularization was defined as complete revascularization when the rSS was 0 (zero) and incomplete revascularization when the rSS was greater than or equal to 1. The SRI represents the proportion of coronary artery disease burden treated percutaneously or surgically and was calculated using the formula: $SRI = (1 - [rSS/bSS]) \times 100$.

Major cardiovascular events were defined as the presence of one or more of the following diagnoses at follow-up: all-cause death, cardiac death, reinfarction, or ischemia-guided repeat revascularization.

Procedures

Multiarterial coronary artery disease patients were previously discussed among the members of the institution's Heart Team, where percutaneous or surgical revascularization was decided, according to each case; the number and type of stents, while the techniques used in each PCI were chosen at the discretion of each operator. The number and type of conduits used in each CABG were also at the discretion of each cardiovascular surgeon.

A retrospective evaluation of bSS and rSS was performed in each treatment group, according to the patient's images and clinical history, which were determined by two interventional cardiologists (independent of the decision making and treatments performed), based on previously published studies (www.SYNTAXscore.org) ^(3,19) (Figure 1 shows an example of how these scores were determined in one of the patients in the study).

Subsequently, clinical follow-up was carried out until 2015, by means of the medical records in the electronic file and via telephone. The definition of each cardiovascular event was based on the definitions of the Academic Research Consortium ⁽²⁰⁾.

Statistical analysis

In the descriptive analysis, mean with standard deviation or median with interquartile range was used for continuous variables and absolute and relative frequencies for categorical variables. In the bivariate analysis, the Student's t-test and chi-square test were used. The operating characteristic curves (OCC) for the SRI were determined to assess the relative predictive accuracy at 4-year follow-up. The area under the curve was calculated for the IRS to identify the Youden index (optimal cut-off point) for the primary endpoint. Log-rank test was used for survival analysis and Cox regression for multivariate analysis. A p value < 0.05 was considered statistically significant. The IBM SPSS version 21 statistical program was used.

Ethical aspects

The present study respected the ethical principles of human research: autonomy, nonmaleficence, beneficence, and justice. There was no risk of medical malpractice since it was a cross-sectional study.

Results

Two hundred patients participated in the study. There were no differences in cardiovascular history between the CABG and PCI groups (Table 1). The bSS mean in underwent surgery was 33.5 ± 8.0 , higher than those of treated percutaneously, which was 24.9 ± 7.9 ($p < 0.05$). SRI in the CABG group was 83.2% and

Table 1. Baseline characteristics of the population according to type of revascularization.

Characteristic	CABG group (n = 100)	PCI group (n = 100)	p value
Age (in years)*	60.2 ± 10.5	62.9 ± 9.5	NS
Men	92 (92)	87 (87)	NS
Weight*	76 ± 11.0	76 ± 13	NS
Body mass index*	27.6 ± 4.9	27.7 ± 3.7	NS
Diabetes mellitus type 2	44 (44)	54 (54)	NS
Hypertension	65 (65)	68 (68)	NS
Dyslipidemia	58 (58)	59 (59)	NS
Previous CVD	3 (3)	6 (6)	NS
Previous myocardial infarction	15 (15)	24 (24)	NS
CKD	7 (7)	15 (15)	< 0.05
Smoking	41 (41)	38 (38)	NS
Peripheral artery disease	3 (3)	6 (6)	NS
Hyperuricemia	4 (4)	6 (6)	NS
Family history	3 (3)	4 (4)	NS
Previous PCI	6 (6)	7 (7)	NS
Atrial fibrillation	2 (2)	5 (5)	NS
Creatinine clearance*	87.9 ± 11.56	90.37 ± 31.28	NS
LVEF*	50.0 ± 11.57	46.8 ± 13.1	NS
Baseline SYNTAX Score*	33.5 ± 8.0	24.91 ± 7.88	< 0.05
Residual SYNTAX score**	2.5 (0 -10.25)	3 (0 -9)	0.93
SYNTAX revascularization index*	83 ± 20	79 ± 21	NS
Follow-up time (in months)*	43 ± 14.0	45 ± 13.0	NS

* values expressed in means and standard deviation.

** values expressed in median and minimum and maximum value.

CV: cerebrovascular disease, CKD: chronic kidney disease, CABG: coronary artery bypass grafting, PCI: percutaneous coronary intervention, LVEF: left ventricular ejection fraction, NS: not significant.

The degree of complete revascularization in patients with multiarterial disease is account for around 40%, which is similar to that described in previous studies performed by Faroq⁽³⁾ and Génereux⁽⁴⁾, but lower than the meta-analysis performed by Zimarino *et al.*⁽⁶⁾ in which they reported a complete revascularization rate of around 50%. It was found that the SRI can be considered as a prognostic tool in patients with incomplete coronary revascularization with a cutoff point of 90%, both for CABG and PCI. This result agrees with that obtained by Génereux *et al.*⁽¹⁵⁾ who used the SRI in more than 2200 patients who underwent PCI, with a 1-year follow-up and including patients with acute coronary events; however, the incidence of MACE in that study was higher, which could explain their finding of a lower cut-off point for this index compared to the present study (90% vs. 80%).

It is noteworthy that in this study, rSS was not statistically significant as a prognostic factor, in contrast to several studies that have presented rSS > 8 as a prognostic factor for MACE at 1

year^(4,5,16,17). This may be explained by the small population with lower rates of major cardiovascular events reported in our study.

SRI was a predictor of MACE, which is consistent with previous studies⁽¹⁵⁾. On the other hand, achieving complete revascularization is difficult and not always possible, so that the term “reasonable incomplete revascularization” has been developed. In this sense, achieving an rSS < 8 is an adequate target. However, the individual characterization of the proportion of coronary artery disease by SRI could provide valuable information in decision making on the revascularization method to be chosen since if a reasonable and adequate degree of revascularization is not achieved by PCI, CABG could represent a better alternative in this patients group.

The study has some limitations. It was single-center, with a small sample size, which probably affected the frequency of MACE. The groups were not homogeneous in their initial anatomical complexity by bSS, and some variables could not be adequately

Table 2. Major cardiovascular events (absolute values) in each group at 4-year follow-up.

Major cardiovascular event	Surgery	PCI	p value
Death	2	1	0.561
Cardiovascular death	2	3	0.651
Myocardial infarction	7	10	0.579
Cerebrovascular disease	2	0	0.155
Hemorrhage	11	4	0.060
RVCr	4	11	0.060
Overall	28	29	0.860

PCI: percutaneous coronary intervention, rRCV: repeated revascularization of culprit vessel.

measured since it was retrospective. In addition, the technical details of each treatment group were not taken into account, which could have implied important biases for the results.

In conclusion, the SRI was a useful prognostic tool to measure the degree of revascularization in this group of patients and prevent long-term complications. An SRI $\geq 90\%$ may be an acceptable treatment target, so prospective and randomized studies including a larger sample number may be useful.

Author contributions

CAOZ, YPR and MPD have participated in the study design, review and/or drafting and approval of the final version of the manuscript. TVL also participated in the data analysis.

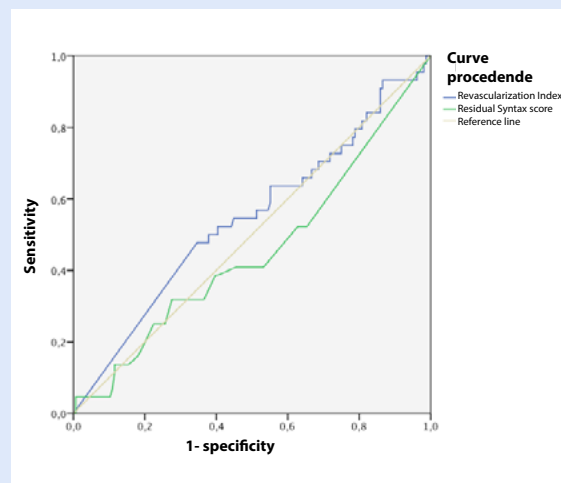


Figure 2. Receiver operating characteristic curve for the prediction of major cardiovascular events at 4-year follow-up. Area under the curve of the SYNTAX revascularization index (SRI): 0.60 ($p=0,05$). Area under the curve of residual SYNTAX: 0.39 ($p=0.045$). SRI of 90%, sensitivity of 67% and specificity of 51%.

Acknowledgments

To the team that makes up the Department of Interventional Cardiology of the INC "Ignacio Chávez" for all the support during the training years in the high specialty, especially to my teachers for their teachings and patience, and my friends for all the support and companionship.

References

1. Fer Neumann FJ, Sousa-Uva M, Ahlsson A, Alfonso F, Banning A, Benedetto U, et al. 2018 ESC/EACTS Guidelines on myocardial revascularization. *Eur Heart J*. 2019;40(2):87-165. doi: 10.1093/eurheartj/ehy394.
2. Hannan EL, Wu C, Walford G, Holmes D, Jones R, Sharma S, et al. Incomplete revascularization in the era of drug-eluting stents: impact on adverse outcomes. *JACC Cardiovasc Interv*. 2009;2(1):17-25. doi: 10.1016/j.jcin.2008.08.021.
3. Farooq V, Serruys P, Bourantas C, 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. *Circulation*. 2013;128(2):141-51. doi: 10.1161/CIRCULATIONAHA.113.001803
4. Généreux P, Palmerini T, Caixeta A, Rosner G, Green P, Dressler O, et al. Quantification and Impact of Untreated Coronary Artery Disease After Percutaneous Coronary Intervention The Residual SYNTAX (Synergy Between PCI With Taxus and Cardiac Surgery) Score. *J Am Coll Cardiol*. 2012;59(24):2165-74. doi: 10.1016/j.jacc.2012.03.010.
5. Hambraeus K, Jensevik K, Lagerqvist B, Lindahl B, Carlsson R, Farzaneh-Far R, et al. Long-Term Outcome of Incomplete Revascularization After Percutaneous Coronary Intervention in SCAAR (Swedish Coronary Angiography and Angioplasty Registry). *JACC Cardiovasc Interv*. 2016;9(3):207-215. doi: 10.1016/j.jcin.2015.10.034.
6. Zimarino M, Ricci F, Romanello M, Di Nicola M, Corazzini A, De Caterina R. Complete Myocardial Revascularization Confers a Larger Clinical Benefit When Performed With State-of-the-Art Techniques in High-Risk Patients With Multivessel Coronary Artery Disease: A Meta-Analysis of Randomized and Observational Studies. *Catheter Cardiovasc Interv*. 2016;87(1):3-12. doi: 10.1002/ccd.25923.
7. Rosner GF, Kirtane AJ, Genereux P, Lansky A, Cristea E, Gersh B, et al. Impact of the presence and extent of incomplete angiographic revascularization after percutaneous coronary intervention in acute coronary syndromes: the Acute Catheterization and Urgent Intervention Triage Strategy (ACUITY) trial. *Circulation*. 2012;125(21):2613-20. doi: 10.1161/CIRCULATIONAHA.111.069237.
8. De Bruyne B. Multivessel disease: from reasonably incomplete to functionally complete revascularization. *Circulation*. 2012;125(21):2557-9. doi: 10.1161/CIRCULATIONAHA.112.106872.
9. Dauerman HL. Reasonable incomplete revascularization. *Circulation*. 2011;123(21):2337-40. doi: 10.1161/CIRCULATIONAHA.111.033126.
10. Kim YH, Park DW, Lee JY, Kim WJ, Yun SC, Ahn JM, et al. Impact of angiographic complete revascularization after drug-eluting stent implantation or coronary artery bypass graft surgery for multivessel

- coronary artery disease. *Circulation*. 2011;123(21):2373-81. doi: 10.1161/CIRCULATIONAHA.110.005041.
11. Taggart DP. Incomplete revascularization: appropriate and inappropriate. *Eur J Cardiothorac Surg*. 2012;41(3):542-3. doi: 10.1093/ejcts/ezr298.
 12. Schwartz L, Bertolet M, Feit F, Fuentes F, Sako E, Toosi M, et al. Impact of completeness of revascularization on long-term cardiovascular outcomes in patients with type 2 diabetes mellitus: results from the Bypass Angioplasty Revascularization Investigation 2 Diabetes (BARI 2D). *Circ Cardiovasc Interv*. 2012;5(2):166-73. doi: 10.1161/CIRCINTERVENTIONS.111.963512.
 13. Gössl M, Faxon DP, Bell MR, Holmes D, Gersh B. Complete versus incomplete revascularization with coronary artery bypass graft or percutaneous intervention in stable coronary artery disease. *Circ Cardiovasc Interv*. 2012;5(4):597-604. doi: 10.1161/CIRCINTERVENTIONS.111.965509.
 14. Ong AT, Serruys PW. Complete revascularization: coronary artery bypass graft surgery versus percutaneous coronary intervention. *Circulation*. 2006;114(3):249-55. doi: 10.1161/CIRCULATIONAHA.106.614420.
 15. Généreux P, Campos CM, Yadav M, Palmerini T, Caixeta A, Xu K, et al. Reasonable incomplete revascularization after percutaneous coronary intervention: the SYNTAX Revascularisation Index. *EuroIntervention*. 2015;11(6):634-42. doi: 10.4244/EIJY14M10_05.
 16. Melina G, Angeloni E, Refice S, Benegiano C, Lechiancole A, Roscitano A, et al. Residual SYNTAX Score and Survival Following Coronary Artery Bypass Grafting: Analysis of 1608 Patients. *Circulation* 2014;130(S2): A16388. doi: 10.1161/circ.130.suppl_2.16388.
 17. Lluberas S, Jubany L, Esmite N. Impact of Untreated Coronary Artery Disease After Percutaneous Coronary Intervention in Patients With Prior CABG: The Residual CABG SYNTAX score. *J Am Coll Cardiol*. 2014;64(11 Suppl):B27. doi: 10.1016/j.jacc.2014.07.119.
 18. Farooq V, Girasis Ch, Magro M, Onuma Y, More MA, Heo JH, et al. 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(11):1277-85. doi: 10.4244/EIJV8I11A196.
 19. Mohr FW, Morice MC, Kappetein AP, Feldman T, Stähle 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(9867):629-38. doi: 10.1016/S0140-6736(13)60141-5.
 20. Cutlip D, Windecker S, Mehran R, Boam A, Cohen D, van Es GA, et al. Clinical End Points in Coronary Stent Trials. *Circulation*. 2007;115(17):2344-51. doi: 10.1161/CIRCULATIONAHA.106.685313.