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# Comparison of SYNTAX Score And Residual SYNTAX Score in Patients Undergoing Multivessel Coronary Intervention

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## ABSTRACT

***Objective***: To associate the SYNTAX score, residual SYNTAX score and in-hospital outcomes in patients who underwent multivessel Percutaneous Coronary Intervention.

***Study Design***: Analytical, cross-sectional Study.

***Place and Duration of Study***: Cardiac Cath Lab, Armed Forces Institute of Cardiology/National Institute of Heart Diseases, Rawalpindi, Pakistan, from Jul to Oct 2023.

***Methodology***: Total three hundred and sixty-six patients who underwent multivessel coronary intervention were included using non-probability consecutive sampling. Patients with history of CABG and complex coronary artery disease were excluded. SYNTAX score and residual SYNTAX score were calculated. Chi-square test and Wilcoxon Signed Rank test were applied to find associations. $p<0.05$ was considered as statistically significant.

***Results***: In a study of 366 participants, 292(79.8%) were males and 74(20.2%) were females whose mean age was 62.01±8.67 years, 136(37.2%) had diabetes, 177(48.4%) were hypertensive, and 153(41.8%) were smokers. NSTEMI was present in 173(47.2%) patients, and 43(11.7%) had LMS disease. In-hospital outcomes included 5(1.4%) repeat revascularization cases, 3(0.8%) Myocardial Infarction cases and 2(0.5%) death cases. SYNTAX Score had insignificant association with mortality ($p=0.05$), while residual SYNTAX score was significantly associated with repeat revascularization, MI, and mortality ($p<0.01$). Pre and post-procedural SYNTAX score were also different significantly ($p<0.001$).

***Conclusion***: Our study underscored the predictive importance of SYNTAX Score and residual SYNTAX Score in guiding optimal treatment decisions for improved outcomes in multivessel coronary intervention.

**Keywords**: Multivessel percutaneous coronary intervention, Residual SYNTAX score, SYNTAX score.

***How to Cite This Article:*** *Mumtaz Z, Khattak ZA, Siddique MB, Rizvi SMA, Bilal A, Ishaq Z. Comparison of SYNTAX Score and Residual SYNTAX Score in Patients Undergoing Multivessel Coronary Intervention. Pak Armed Forces Med J 2024; 74i-(Suppl-1): S38-S42. DOI: https://doi.org/10.51253/pafmj.v74i-SUPPL-1.11447*



## INTRODUCTION

Coronary revascularization includes a heterogeneous group of treatments, especially for multivessel Coronary Artery Disease (CAD). It can be achieved via Percutaneous Coronary Intervention (PCI) or Coronary Artery Bypass Grafting (CABG). Successful PCI to a target vessel is considered if there is visual accomplishment of Thrombolysis In Myocardial Infarction-III (TIMI-III) flow with <50% residual diameter stenosis.[1] The extent of CAD can be measured by the SYNTAX (Synergy between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery) score (SS). The SS is defined as an angiographic tool that quantifies CAD based on lesion number, location and complexity. Its comprehensive assessment includes not only the enumeration of lesion numbers but also detailed considerations of their precise locations and complexities. The higher score defines the increased complexity of disease; a low score defined as <22, and intermediate score as 23-32, and high score as >32.[2,3] After complete revascularization of the lesions, the SYNTAX scorecalculated of the residual lesions measured as residual SYNTAX score (rSS) is independently associated with mortality, major adverse cardiovascular events and repeat revascularization.[4]

The findings from a SYNTAX study done by Rodriguez *et al*. have significantly contributed to our understanding of treatment outcomes in patients with three-vessel disease, whether with or without left main stenosis. According to this study, the mortality rates associated with PCI utilizing drug-eluting stents and CABG were found to be equivalent. However, a notable observation was a higher risk of repeat revascularization following PCI compared to CABG. Interestingly, there was a converse relationship, as PCI was associated with a decreased risk of stroke compared to CABG in this specific patient cohort.[4]

The rSS is the SS remaining after completion of PCI, including cases of staged PCI procedures.[4-6] The

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calculation of rSS quantitatively assesses the angiographic completeness of revascularization after PCI. It was found that higher rSS results in poor outcomes in patients undergoing revascularization via PCI.[6] The patients with low rSS (<8) and 5% ischemic reduction after revascularization had the best prognosis than those with high rSS>8.[3,7] The predictive value of rSS has been demonstrated in hemodynamically stable patients with chronic coronary syndrome, ACS and MI. rSS is a global marker of severity that outweighs benefits of revascularization.[8] rSS is a strong predictor of long term adverse events in a population of three vessel or left main coronary artery disease patients treated by PCI.[9]

Current practice guidelines recommend using coronary lesion anatomy and the SS to guide revascularization strategy selection. This approach underscores the importance of a comprehensive assessment, aligning with established recom-mendations for informed decision-making in revascularization strategies. This recommendation is particularly pertinent for stable patients with CAD who are contemplating either PCI or CABG.[10]

The data regarding association of SS and rSS with outcomes is lacking and there is no local data published in this regard. The absence of locally published data on this critical aspect necessitated a comprehensive investigation to bridge this gap and to contribute substantially to the understanding of the prognostic implications of SS and rSS.

The study aimed to investigate the associations between SS, rSS, and various in-hospital outcomes, including mortality, repeat revascularization, and myocardial infarction, thereby providing valuable insights for optimizing the management of multivessel coronary artery disease.

## METHODOLOGY

This Analytical, Cross-sectional study was conducted from July to October 2023 at Armed Forces Institute of Cardiology/National Institute of Heart Diseases, Rawalpindi, Pakistan, after taking ethical approval from Institutional Ethical Review Board (IERB Ltr# 9/2/R&D/2023/277).

With reference to the 39% prevalence of multivessel coronary intervention, calculated sample size was 366 on WHO sample size calculator at 95% confidence level and 5% margin of error. [11]

**Inclusion Criteria:** All patients of both gender with age between 18-80 years who underwent multivessel coronary intervention were included.

**Exclusion Criteria:** Patients with history of CABG and those with complex coronary artery disease unsuitable for PCI were excluded from study.

SS and rSS of patients who underwent multivessel coronary intervention were calculated using visual assessment of angiographic lesions. SS ≤22 was considered low score, 23 to ≤32 was considered intermediate score and >32 score was considered high SS.3 rSS was graded into 4 categories; Grade 1(0), Grade 2(1-3), Grade 3(4-8) and Grade 4(>8).[12]

Cases were enrolled by non-probability consecutive sampling technique. SYNTAX score was calculated after initial diagnostic coronary angiography. Residual SYNTAX score was calculated Post PCI i.e. after CABG declined multivessel coronary intervention.

Data analysis was done on Statistical Package for the Social Sciences (SPSS) version 23:00. Quantitative variables such as age, SYNTAX score, and residual SYNTAX score were presented as Mean±SD, and qualitative variables such as repeat revascularization, myocardial infarction were presented as frequencies and percentages. Chi-square was applied to find association between variables. Wilcoxon Signed Rank test was applied to find the relationship between SYNTAX score and residual SYNTAX Score. *p*-value <0.05 was considered as statistically significant.

## RESULTS

Total 366 participants were included in study; out of these, majority were males 292(79.8%). Mean age of study sample was 62.01±8.67 years. Diabetics were 136(37.2%), 177(48.4%) were hypertensive, and 153(41.8%) were smokers. Patients with previous history of MI and PCI were 92(25.1%) and 47(12.8%) respectively. Mean ejection fraction noted was 49.16±6.89%. Majority of the patients presented with NSTEMI 173(47.2%). LMS disease was present in 43(11.7%) patients. Among in-hospital outcomes, repeat revascularization was performed in 5(1.4%) patients, MI occurred in 3(0.8%) patients and 2(0.5%) patients died. (Table-I)

Study outcomes were determined in association with SYNTAX score and residual SYNTAX score, providing a comprehensive analysis of their respective impacts on the results and contributing valuable insights to the overall assessment. There was insignificant association of SS with repeat revascularization, MI and mortality ($p$>0.05). In terms of rSS, all the 3 outcome variables (repeat revascularization, MI and mortality) were significantly associated with

rSS ($p$<0.01). There were 5(1.4%) repeat revascularized cases, 3(0.8%) were MI cases and 2(0.5%) were mortality cases. Among revascularized cases, 1 had Grade-2 rSS, 2 had Grade-3 rSS and 2 had Grade-4 rSS. 2 MI cases had Grade-3 rSS, 1 case had Grade-4 rSS and all mortality cases had Grade-4 rSS as shown in (Table-II).

**Table-I: Frequency Distribution of Baseline and Clinical Parameters of Study Participants (n=366)**

| Variable | | Frequency (%) |
|---|---|---|
| Gender | Male | 292(79.8) |
| | Female | 74(20.2) |
| Diabetes | Yes | 136(37.2) |
| | No | 230(62.8) |
| Hypertension | Yes | 177(48.4) |
| | No | 189(51.6) |
| Smoker | Yes | 153(41.8) |
| | No | 213(58.2) |
| Hypercholesterolemia | Yes | 109(29.8) |
| | No | 257(70.2) |
| History of MI | Yes | 92(25.1) |
| | No | 274(74.9) |
| History of PCI | Yes | 47(12.8) |
| | No | 319(87.2) |
| Acute Coronary Syndrome | STEMI | 81(22.1) |
| | NSTEMI | 173(47.2) |
| | UA | 112(30.6) |
| LMS Disease | Yes | 43(11.7) |
| | No | 323(88.3) |
| Repeat Revascularization | Yes | 5(1.4) |
| | No | 361(98.6) |
| Myocardial Infarction | Yes | 3(0.8) |
| | No | 363(99.2) |
| Mortality | Yes | 2(0.5) |
| | No | 364(99.5) |

*MI=Myocardial Infarction; PCI=Percutaneous Coronary Intervention; LVEF= Left Ventricular Ejection Fraction; LMS=Left Main Stem*

Comparison of SYNTAX score and residual SYNTAX Score revealed statistically significant difference in pre and post-procedural score ($p$<0.001) as shown in Table-III.

**Table-III: Relationship Between SYNTAX Score and Residual SYNTAX Score (n=366)**

| Comparison of Scores | SYNTAX Score Median(IQR) | Residual SYNTAX Score Median(IQR) | $p$-value |
|---|---|---|---|
| | 26(21-32) | 2(0-3) | <0.001 |

## DISCUSSION

Coronary revascularization strategies, such as PCI and CABG, play a pivotal role in managing multivessel CAD. This study was done to explore the association between SS, rSS, and in-hospital outcomes in patients who underwent multivessel coronary intervention.

The utilization of SS, a comprehensive angiographic tool, allowed us to quantify the complexity of CAD based on lesion characteristics. The significance of SS lies in its ability to guide treatment decisions, helping in identifying patients who may benefit from either PCI or CABG. In our study, a higher SS was associated with increased complexity of disease, consistent with existing literature.[13-17]

The observed association between outcomes (repeat revascularization, MI and mortality) and SYNTAX score in our study suggested that the overall SS had insignificant association with outcomes ($p$>0.05), while the residual burden of disease measured by rSS were significantly associated with the aforementioned outcomes ($p$<0.01). This underscores

**Table-II: Association of Outcomes with SYNTAX Score and Residual SYNTAX Score (n=366)**

| Outcomes | | SYNTAX Score | | | | $p$-value |
|---|---|---|---|---|---|---|
| | | Low(≤22) (Total=117) Frequency (%) | Intermediate (23-32) (Total=167) Frequency (%) | High (>32) (Total=82) Frequency (%) | | |
| Repeat Revascularization | Yes | 1(0.9) | 2(1.2) | 2(1.2) | | 0.71 |
| | No | 116(99.1) | 165(98.8) | 80(97.6) | | |
| Myocardial Infarction | Yes | 0(0.0) | 1(0.6) | 2(2.4) | | 0.15 |
| | No | 117(100.0) | 166(99.4) | 80(97.6) | | |
| Mortality | Yes | 0(0.0) | 0(0.0) | 2(2.4) | | 0.05 |
| | No | 117(100.0) | 167(100.0) | 80(97.6) | | |
| **Outcomes** | | **Residual SYNTAX Score** | | | | **$p$-value** |
| | | **Grade 1 (0) (Total=136) Frequency (%)** | **Grade 2 (1-3) (Total=152) Frequency (%)** | **Grade 3 (4-8) (Total=48) Frequency (%)** | **Grade 4 (>8) (Total=30) Frequency (%)** | |
| Repeat Revascularization | Yes | 0(0.0) | 1(0.7) | 2(4.2) | 2(6.7) | 0.008 |
| | No | 136(100.0) | 151(99.3) | 46(95.8) | 28(93.3) | |
| Myocardial Infarction | Yes | 0(0.0) | 0(0.0) | 2(4.2) | 1(3.3) | 0.009 |
| | No | 136(100.0) | 152(100.0) | 46(95.8) | 29(96.7) | |
| Mortality | Yes | 0(0.0) | 0(0.0) | 0(0.0) | 2(6.7) | 0.007 |
| | No | 136(100.0) | 152(100.0) | 48(100.0) | 28(93.3) | |

the importance of not only considering the initial lesion complexity but also ensuring effective revascularization to optimize patient outcomes. However, the literature indicates a statistically significant association between residual SYNTAX Score (rSS) and all three variables of mortality, repeat revascularization, and MI ($p$<0.01). It is also inline to the significant findings ($p$=0.002) reported by Safarian *et al*.[18]

Another study done by Choudhary *et al*., also reported a similar significant association between mortality and higher SS in patients undergoing PCI. In this study, patients with high SS had a mortality of 18.6% as compared to no mortality in patients with low SS ($p$=0.01). Similar association was also present in terms of repeat revascularization, and MI ($p$=0.001).[19] These findings deviated from our study, which disclosed a subtle correlation between SS and mortality. In contrast, the associations of SS with repeat revascularization and myocardial infarction were statistically insignificant, with $p$-values of 0.15 and 0.71, respectively.

The concept of rSS, representing the remaining SS after complete revascularization via PCI, emerged as a key focus of our investigation. Our findings underscored the clinical relevance of rSS, demonstrating a strong association with adverse outcomes, including repeat revascularization, myocardial infarction (MI), and mortality ($p$<0.01). The association between rSS and poor outcomes aligns with previous research, emphasizing the importance of achieving complete revascularization.[12,20,21]

Malkin *et al*., studied 240 patients with triple vessel CAD who underwent PCI. A reduced mortality of 2.5% was reported in patients with rSS of zero vs 12.5% in those with higher rSS ($p$=0.003).[20]

Similarly, in a study done by Takashi *et al*, patients achieving complete revascularization (rSS of 0) showed no significant difference in the 10-year all-cause death risk compared to those with rSS ≤8. However, individuals with rSS >8 had over threefold higher risk of 10-year all-cause death than those with rSS of 0. In alignment with our findings, this study also highlighted the importance of achieving a lower rSS, emphasizing its consistent impact on mortality.[21]

Farooq *et al*., also observed concordant results, indicating that a residual SYNTAX Score >8 correlated with a 35.3% all-cause mortality at 5 years ($p$<0.001), consistent with our study's findings.

A meta-analysis conducted by Nagaraja *et al*., encompassed 38 studies and 1,56,240 patients, concluded a significant reduction in mortality among patients with complete revascularization and low rSS, accompanied by a decreased incidence of myocardial infarction and repeat revascularization.[22]

Our study population, comprising patients with multivessel CAD who underwent PCI due to CABG refusal, reflected real-world clinical scenarios. The decision-making process in such cases is challenging, and the use of SS and rSS provides valuable insights into the anatomical severity of lesions and the completeness of revascularization.

## LIMITATIONS OF STUDY

It is important to acknowledge the limitations of our study, including its cross-sectional design and the reliance on angiographic assessment for SS and rSS calculation. The cross-sectional design of our study was chosen for its practicality, but it limits the establishment of causal relationships or the tracking of changes over time. Furthermore, reliance on angiographic assessment for SS and rSS calculation introduces potential measurement variability, emphasizing the need for future research employing longitudinal designs and standardized measurement techniques for a more comprehensive understanding of the observed associations.

## CONCLUSION

This study emphasized the clinical significance of SS and, more importantly, rSS in predicting adverse outcomes in patients undergoing multivessel coronary intervention. These findings supported the use of these metrics in guiding treatment decisions and optimizing revascularization strategies for improved patient outcomes.

## ACKNOWLEDGEMENT

I am deeply grateful to my supervisor for his guidance, patience and support who provided insight and expertise that greatly assisted my research project. I also want to share my gratitude for Comdt Exec Dir AFIC/NIHD & R&D department for their support and contribution in completion of the research paper.

**Conflict of Interest**: None

**Authors' Contribution**

Following authors have made substantial contributions to the manuscript:

ZM & ZAK: Concept, study design, critical review, drafting the manuscript, approval of the final version to be published

MBS & SMAR: Concept, data acquisition, approval of the final version to be published

AB & ZI: Data acquisition, data analysis, data interpretation, drafting the manuscript

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity

of any part of the work are appropriately investigated and resolved.

## REFERENCES


1. Price MJ, Boutis L, Kirtane AJ, Chetcuti S, Poliačiková P, Dens J, et al. Three-year outcomes after bifurcation stenting with zotarolimus-eluting stents: Final results from the RESOLUTE ONYX postapproval study. J Soc Cardiovasc Angiogr Interv 2023; 2(6): 101116. http://doi.org/10.1016/j.jscai.2023.101116
2. Scudeler TL, Farkouh ME, Hueb W, Rezende PC, Campolina AG, Martins EB, et al. Coronary atherosclerotic burden assessed by SYNTAX scores and outcomes in surgical, percutaneous or medical strategies: a retrospective cohort study. BMJ Open 2022; 12(9): e062378. Available from: http://doi.org/10.1136/bmjopen-2022-062378
3. Hayase M, Yoda S, Hatta T, Hori Y, Monno K, Fujito H, et al. Prognostic significance of the residual SYNTAX score and ischemic reduction detected with nuclear cardiology for prediction of major cardiac events after revascularization. Intern Med . 2020; 59(11): 1361–71. http://doi.org/10.2169/internalmedicine.3397-19
4. Rodriguez AE, Fernandez-Pereira C, Mieres J, Mendoza J, Sartori F. Can We Improve the Outcomes of Multivessel Disease Using Modified SYNTAX and Residual SYNTAX Scores? Curr Cardiol Rep. Curr Cardiol Rep 2017; 19(3).
5. Morici N, Alicandro G, Ferri LA, Piatti L, Grosseto D, Sganzerla P, et al. Residual SYNTAX score and one-year outcome in elderly patients with acute coronary syndrome. CJC Open 2020; 2(4): 236–43. http://doi.org/10.1016/j.cjco.2020.03.005
6. Kobayashi Y, Lønborg J, Jong A, Nishi T, De Bruyne B, Høfsten DE, et al. Prognostic value of the residual SYNTAX score after functionally Complete Revascularization in ACS. J Am Coll Cardiol 2018; 72(12): 1321–9. http://doi.org/10.1016/j.jacc.2018.06.069
7. Li C, Li J-Y, Feng D-J, Yang X-C, Wang L-F, Xia K. et al. Holistic review and meta-analysis of independent impact of the residual SYNTAX score on prognosis in patients with acute coronary syndrome. Scand Cardiovasc J 2022; 56(1): 187–97. http://doi.org/10.1080/14017431.2022.2095434
8. Barthélémy O, Rouanet S, Brugier D, Vignolles N, Bertin B, Zeitouni M, et al. Predictive value of the residual SYNTAX score in patients with Cardiogenic Shock. J Am Coll Cardiol 2021; 77(2): 144–55. http://doi.org/10.1016/j.jacc.2020.11.025
9. Yan L, Li P, Wang Y, Han D, Li S, Jiang M, et al. The incremental prognostic value of the clinical residual SYNTAX score for patients with chronic renal insufficiency undergoing percutaneous coronary intervention. Front Cardiovasc Med [Internet] 2021; 8. Available from: http://doi.org/10.3389/fcvm.2021.647720
10. Schwietz T, Spyridopoulos I, Pfeiffer S, Laskowski R, Palm S, DE Rosa S, et al. Risk stratification following complex PCI: clinical versus anatomical risk stratification including "post PCI residual SYNTAX-score" as quantification of incomplete revascularization: Risk stratification following complex pci. J Interv Cardiol 2013; 26(1): 29–37. http://doi.org/10.1111/j.1540-8183.2013.12014.x
11. Mostafa Abdelmonaem MD, Reda A, Nour A. Correlation Between Ankle Brachial Index and SYNTAX Score to Predict Severity of Coronary Artery Disease. Vasc Dis Manag 2021; 18(3).
12. 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. Circulation 2013; 128(2): 141–51. http://doi.org/10.1161/circulationaha.113.001803
13. Lee JM, Hwang D, Choi KH, Lee H-J, Song YB, Cho Y-K, et al. Prognostic impact of residual anatomic disease burden after functionally complete revascularization. Circ Cardiovasc Interv 2020; 13(9). http://doi.org/10.1161/circinterventions.120.009232
14. 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(2): 170–9. http://doi.org/10.1007/s00380-020-01680-3
15. Zenati MA, Habertheuer A, Stock E, Arshanskiy M, Hattler B, Dematt E, et al. Abstract 9602: Higher anatomical syntax score is associated with lower survival after CABG in the REGROUP trial. Circulation 2022; 146(Suppl_1). http://doi.org/10.1161/circ.146.suppl_1.9602
16. Balakrishnan V, Sankaran R, Thanikachalam, Muralidharan, Senguttuvan NB, Ramkumar B. et al. Relevance of syntax score as a marker of complex coronary artery disease and plaque burden in young coronary artery disease - A single centre multifactorial analysis. J Evol Med Dent Sci 2019; 8(40): 3039–43. https://www.jemds.com/data_pdf/ramesh%20sankaran--oct-7-.pdf
17. Nam CW, Fearon WF. Role of the functional SYNTAX score in evaluating multivessel coronary artery disease. Interventional Cardiology 2011 Dec 1; 3(6): 695.
18. Alidoosti M, Shafiee A, Salarifar M, Poorhosseini H, Nematipour E, Safarian H. et al. The SYNTAX score can predict major adverse cardiac events following percutaneous coronary intervention. Heart Views 2014; 15(4): 99 http://doi.org/10.4103/1995-705x.151081
19. Choudhary S. Association of SYNTAX score with short-term outcomes among acute ST-elevation myocardial infarction patients undergoing primary PCI. Indian Heart 2017 [cited 2024 Jan 11]; 69(Suppl 1): S20–3: http://doi.org/10.1016/j.ihj.2016.08.002
20. Malkin CJ, George V, Ghobrial MSA, 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(11): 1286–95. http://doi.org/10.4244/eijv8i11a197
21. Takahashi K, Serruys PW, Gao C, Ono M, Wang R, Thuijs DJFM, et al. Ten-year all-cause death according to completeness of revascularization in patients with three-vessel disease or left main coronary artery disease: Insights from the SYNTAX Extended Survival study. Circulation 2021; 144(2): 96–109. http://doi.org/10.1161/CIRCULATIONAHA.120.046289
22. Nagaraja V, Ooi S-Y, Nolan J, Large A, De Belder M, Ludman P, et al. Impact of incomplete percutaneous revascularization in patients with multivessel coronary artery disease: A systematic review and meta-analysis. J Am Heart Assoc 2016; 5(12). http://doi.org/10.1161/jaha.116.004598