Open Access

Original Article

ADULT CARDIOLOGY

Lesion Characteristics of Chronic Totally Occluded Coronary Arteries on Computed Tomography Angiography in Patients with and without Prior Coronary Artery Bypass Graft

Junaid Arshad, Muhammad Bilal Siddique, Iftikhar Ahmed, Abdul Hameed Siddiqui, Muhammad Shehram, Ali Abbas, Bakht Umar Khan

Department of Adult Cardiology, Armed Forces Institute of Cardiology/National Institute of Heart Diseases/ National University of Medical Sciences (NUMS) Rawalpindi, Pakistan,

ABSTRACT

Objective: To study the differences in characteristics of Chronic Totally Occluded coronary artery lesions on computed tomography angiography in patients with and without prior Coronary Artery Bypass Graft.

Study Design: Comparative cross-sectional Study.

Place and Duration of Study: Armed Forces Institute of Cardiology/National Institute of Heart Diseases, Rawalpindi Pakistan, from Feb to Jul 2023.

Methodology: The study included ninety six patients, with 48 patients in each group (prior CABG and non-CABG). Patients presenting with chest pain and having Chronic Totally Occluded lesions on Computed Tomography Angiography were selected using non-probability consecutive sampling. Data was analyzed using SPSS-23:00. Chi-square test was applied to find the association of lesion characteristics in study groups and level of significance was taken <0.05.

Results: This study analyzed the characteristics of lesions in different target vessels among n= 96 patients, with 74(77.1%) being males and 22(22.9%) females. The mean age was 61.98±8.04 years. No statistically significant distinctions in the distribution of target vessels were observed when comparing the two groups. (p=0.48). However, osteal lesions had higher prevalence in the CABG group 20(41.7%) (p=0.04). The presence of blunt stump [21(43.8) vs 18(37.5); p=0.67] and calcification [(20(41.7%) vs 21(43.8%), p=1.00)] had no significant divergence between CABG and non-CABG groups. Bending was more common in the CABG group 17(35.4%) (p=0.002). In the CABG group, a higher occurrence of a side branch at the proximal cap 22(45.8%) (p=0.01) as well as a distal cap at the bifurcation 20(41.7%) (p<0.001), was noted.

Conclusion: Chronic Totally Occluded lesions were more intricate in prior CABG patients, posing greater challenges for recanalization.

Keywords: Chronic Total Occlusion, Computed tomography angiography, Coronary artery bypass graft.

How to Cite This Article: *Arshad J, Siddique MB, Ahmed I, Siddiqui AH, Shehram M, Abbas A, Khan BU. Lesion Characteristics of Chronic Totally Occluded Coronary Arteries on Computed Tomography Angiography in Patients with and without Prior Coronary Artery Bypass Graft. Pak Armed Forces Med J 2024; 74(Suppl-1): S43-S47. DOI: https://doi.org/10.51253/pafmj.v74i-SUPP-1-10801*

INTRODUCTION

Chronic Total Occlusion (CTO) refers to a coronary artery that is entirely blocked, lacking antegrade flow, denoted as Thrombolysis in Myocardial Infarction (TIMI) 0 flow, that persists for 3 months or more. CTO Percutaneous Coronary Intervention (PCI) is a complex procedure with risks of complications hence only 10-15% of patients undergo PCI for CTO and a large number are treated with coronary artery bypass graft (CABG) surgery.[1-3]

However, it is noted that CABG itself accelerates the process of coronary artery atherosclerosis in native vessels and this can lead to a new native vessel CTO formation in up to 43% of patients as early as 1-year post-CABG surgery.[4] Native artery CTO occurs in post CABG patients at a higher rate of 54%, compared to patients without a history of CABG.[5] Furthermore, undergoing a repeat CABG surgery is linked to unfavorable long-term results when compared to the initial CABG procedure. Add-itionally, performing PCI on vein grafts is connected to elevated rates of failure.[6-8]

Several experts have identified previous CABG serving as an indicator of technical failure in CTO cases PCI.[9] Examination of CTO lesions through pathological analysis in patients with prior CABG has unveiled higher levels of inflammation, fibrosis, calcification, and adverse remodeling compared to patients who haven't undergone CABG. Consequently, previous CABG has been in-corporated as a risk determinant for procedural technical failure within the scoring system known as the Registry of Cross Boss and Hybrid Procedures in France, the Nether-lands, Belgium, and the United Kingdom (RECHARGE) score.[9]

Correspondence: Dr Junaid Arshad, Department of Adult Cardiology, AFIC/NIHD, Rawalpindi Pakistan

Owing to the remarkable progress in revascularization techniques over the past decade, the rate of success in CTO PCI procedures by experienced operators is as high as 90%[10] but this is true for patients without prior CABG. Due to the complex atherosclerotic pathology of native vessels in post-CABG patients, CTO PCI is challenging with a relatively higher failure rate.

By defining the differences in characteristics of CTO lesions in our study population, we can determine the challenges during the PCI of CTO lesions, which could enhance the success rate of future CTO PCI endeavors. There is no local data available and literature is scarce on this subject. Therefore, the current study aimed to investigate the lesion characteristics of chronic totally occluded coronary arteries on computed tomography angiography (CTA) among patients with and without a history of previous CABG.

METHODOLOGY

This study represents a Comparative Cross-sectional investigation carried out at Armed Forces Institute of Cardiology/National Institute of Heart Diseases, Rawalpindi Pakistan after approval from the Institutional Ethical Review Board (IERB) (letter# 9/2/R&D/2023/242) from February to July 2023.

Sample size of n=12 for each study group was calculated by two group method using 24.9% and 75.1% prior CABG and Non-CABG status in CTO patients respectively by keeping 95% confidence interval and a 5% margin of error. However, we had collected data from n=96 participants with 48 patients in each group (prior CABG and non-CABG).[11]

Inclusion Criteria: All patients of age 18-80 years with either gender presenting with chest pain and having CTO lesions on CT angiography with or without prior CABG.

Exclusion Criteria: Patients presenting with unstable angina, non-ST-segment elevation myocardial infarction, ST-segment elevation myocardial infarction, prior PCI, nephropathy, pregnancy, and a history of contrast allergy were excluded from the study.

CTO was characterized as a coronary artery fully obstructed with no antegrade flow (TIMI-0), occurring within a span of three months.[12] (Figure-1). Data was collected from the hospital's CT angiography department by using consecutive sampling technique. CT angiograms were done on Aquillion ONE 640 slice machine by Canon Company and the results were viewed on Vitrea workstation.[7] Patients with totally occluded coronary arteries were shortlisted on a daily basis. Later, the CT angiographies were interpreted by experienced cardiologists.

The collected data was entered into an Excel spreadsheet and subsequently transferred to Statistical Package for Social Sciences (SPSS) version 23:00 for analysis. We utilized descriptive statistics to summarize the variables like age, gender, and comorbid like hyper-tension, diabetes, and dyslipidemias. Inferential statistics such as chi-square was applied for comparison of the lesion characteristics (e.g. blunt stump, osteal lesion, and calcification) between the two groups (prior CABG and non-CABG). Level of significance was taken as <0.05

RESULTS

A total of ninety six patients were included in the analysis, of which 74(77.1%) were males and 22(22.9%) were females. The mean age of the participants was 58.33±7.35 years and 63.63±7.90 years in prior CABG and non-CABG groups respectively (Table-I).

Table-I: Demographics and Comorbid of Study Participants (n=96)

Variables		CABG Group (Total =48) Frequency(%)	Non-CABG Group (Total=48) Frequency(%)
Gender	Male	34 (70.8)	40(83.3)
	Female	14(29.2)	8(16.7)
Age (years) (Mean+SD)		58.33±7.35	63.63 ± 7.90
Comorbid	Diabetes	25(52.1)	21(43.8)
	Hypertension	23(50.0)	31(62.0)
	Dyslipidemia	25(52.1)	27(56.3)

The analysis focused on the lesion characteristics of different target vessels in each group. When CABG and non-CABG groups were compared, Right Coronary Artery (RCA) was the target vessel in 19(39.6%) and 24(50.0%) patients respectively. However, this difference was not statistically significant (p=0.48).

The frequency of osteal lesions 20(41.7%) vs 10(20.8%), bending 17(35.4%) vs 4(8.3%), side branch at proximal cap 22(45.8%) vs 10(20.8%), and distal cap

at bifurcation 20(41.7%) vs 1(2.1%) were notably elevated within the CABG group when compared with the non-CABG group respectively. However, association was significant (p<0.05) for all afore-mentioned variables except blunt stump (p=0.67). Regarding calcification, it was observed in 20(41.7%) and 21(43.8%) patients in the CABG and non-CABG group (p>0.05). In case of lesion length, >20mm long lesions were seen more frequently within the non-CABG group, in comparison to the CABG group i.e., 32(66.7%) vs 21(43.7%), respectively and the findings exhibited statistical significance as p-value was <0.001. (Table-II)

Table-II: Comparative Outcomes of Lesion Characteristics between prior CABG and non-CABG groups (n=96)

Lesion characteristics		CABG group (Total=48) Frequency(%)	Non-CABG Group (Total=48) Frequency(%)	*p*-value
Target vessel	LAD	17(35.4)	16(34.4)	0.48
	LCx	12(25.0)	8(16.7)	
	RCA	19(39.6)	24(50.0)	
Osteal lesion		20(41.7)	10(20.8)	0.04
Blunt stump		21(43.8)	18(37.5)	0.67
Calcification		20(41.7)	21(43.8)	1.00
Bending		17(35.4)	4(8.3)	0.002
Side branch at proximal cap		22(45.8)	10(20.8)	0.01
Distal cap at bifurcation		20(41.7)	1(2.1)	<0.001
Lesion Length (mm)	<10mm	3(6.3)	10(20.8)	<0.001
	10-20mm	24(50.0)	6(12.5)	
	>20mm	21(43.7)	32(66.7)	

LAD=Left Anterior Descending; LCx=Left circumflex; RCA= Right Coronary Artery; CABG=Coronary Artery BypassGraft

Figure-1: CT-Angiography showing totally occluded LAD

DISCUSSION

Our results provided valuable insights into the differences in lesion characteristics between two patient groups (prior CABG and non-CABG) that helped us to determine the high success rate of CTO PCI[13-16] in non-CABG group in comparison to post-CABG group.[17,18] Lesion characteristics were assessed and frequency of osteal lesions, bending, side branch at proximal cap and distal cap at bifurcation were notably greater within the CABG group when compared to the non-CABG group. However, association was significant (p<0.05) for all afore-mentioned variables except blunt stump (p=0.67). Regarding calcification, it was more prevalent in non-CABG group, with insignificant result (p>0.05). Similarly, >20mm long lesions were seen more frequently in the non- CABG group as compared to CABG group and the results were statistically significant as p-value was <0.001.

Target vessels in both the CABG and non-CABG groups were assessed. We observed no statistically significant distinction between the two groups in terms of the target vessels, including the left anterior descending artery (LAD), the left circumflex artery (LCx), and the right coronary artery (RCA). These findings indicated that the distribution of occluded coronary arteries is com-parable between patients with and without a history of prior CABG surgery. These results were consistent with the results of Suarez *et al*, who also reported no significant differences in the distribution of CTO lesions between the two patient groups.[19]

For osteal lesions, our analysis revealed a statistically significant disparity between the CABG and non-CABG groups, with a greater prevalence of osteal lesions in the CABG group. This observation has important clinical implications as osteal lesions may pose challenges during PCI procedures. Budassi *et al*, demonstrated a similar higher incidence of osteal lesions in post-CABG patients.[20]

The presence of a blunt stump was another characteristic evaluated in our study. Although there was a slightly higher prevalence of blunt stump in the CABG group compared to the non-CABG group, the difference was not statistically significant. These findings suggested that the presence of a blunt stump may not be influenced by prior CABG surgery. Our results were contrary to those demonstrated by Skakura *et al*, who demonstrated a higher incidence of the blunt stump in post-CABG patients.[21]

Calcification is a common feature observed in CTO lesions and can impact the success of PCI. Our analysis did not reveal a statistically significant

variation in calcification between the CABG and non-CABG groups. These findings suggested that the presence and severity of calcification in CTO lesions were not significantly affected by prior CABG surgery. Contrary to our study, Budassi *et al*, showed a higher incidence (77.4%) of calcification in post-CABG patients, as compared to 54.2% in non-CABG group.[20]

Presence of bending in CTO lesions was also evaluated. The results of the current study exhibited a statistically significant difference between the CABG and non-CABG groups, with a greater prevalence of bending in the CABG group. This finding indicated that prior CABG surgery may contribute to the development of bending in CTO lesions. Bending can pose challenges during PCI, affecting the success rates and procedural outcomes. Our results were akin to those documented by Budassi *et al*.[20]

Additionally, the presence of a side branch at the proximal cap and a distal cap at the bifurcation of CTO lesions revealed significant disparities between the CABG and non-CABG groups for both characteristics. Both variables were more common in the CABG group. These results implied that prior CABG surgery may influence the morphology and configuration of CTO lesions, potentially due to the altered anatomy resulting from the grafts placed during the surgery. These results aligned with prior research that documented differences in the morphology and configuration of CTO lesions in patients with and without prior CABG surgery.[20]

Another important parameter that determines the complexity of a CTO is lesion length. The results shown in our study were inconsistent to that reported by Suarez *et al*, which showed longer lesions of >20mm in post-CABG patients as compared to non-CABG group.[19] This study provided important insights into the characteristics of CTO lesions on CTA in patients with and without prior CABG surgery. Our findings indicated that prior CABG surgery may be linked to a heightened risk of osteal lesions, the development of bending, a side branch at the proximal cap, and a distal cap at the bifurcation of CTO lesions. Lesion length of >20mm was significantly in-creased in non-CABG patients. However, no notable distinctions were noted in the distribution of target vessels, the presence of a blunt stump, or the extent of calcification. These results contributed to the existing body of knowledge and support the importance of considering the history of CABG surgery when evaluating and planning interventions for patients with CTO lesions.

LIMITATIONS OF STUDY

Sample size was relatively small, potentially restricting the applicability of the results. Additionally, the study was confined to a single center, possibly curbing the broader applicability of the findings to other settings.

CONCLUSION

In conclusion, lesion characteristics of chronic totally occluded coronary arteries are more prevalent in prior-CABG patients, emphasizing the influence of prior CABG surgery on osteal lesions, bending, presence of a side branch at the proximal cap, and distal cap at the bifurcation. These findings have potential implications regarding defining the complexity of CTO PCI in post-CABG patients, the risks of complications, optimizing treatment strategies, and improving patient outcomes in CTO management.

ACKNOWLEDGEMENT

I am thankful to my supervisor for giving the concept of the study and guiding me through the whole process. I am also very grateful and want to share my gratitude for Comdt Exec Dir AFIC/NIHD, R&D team for their support and guidance that lead to completion of this study.

Conflict of Interest: None

Authors' Contribution

Following authors have made substantial contributions to the manuscript:

JA & MBS: Concept, drafting the manuscript, data analysis, approval of final version to be published

IA & AHS: Study design, data acquisition, critical review, approval of final version to be published

MS, AA & BUK: Study design, data interpretation critical review, approval of final version to be published

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. Koelbl CO, Nedeljkovic ZS, Jacobs AK. Coronary chronic total occlusion (CTO): A review. Rev Cardiovasc Med 2018; 19(1): 33–9. Available from:. https://doi.org/10.31083/j.rcm.2018.01.896
2. Guo L, Wu J, Zhong L, Ding H, Xu J, Zhou X, et al. Two-year clinical outcomes of medical therapy vs. revascularization for patients with coronary chronic total occlusion. Hellenic J Cardiol . 2020; 61(4): 264–71. https://doi.org/10.1016/j.hjc.2019.03.006
3. Werner GS, Glaser P, Coenen A, Moehlis H, Tischer K-H, Koch M, et al. Reduction of radiation exposure during complex interventions for chronic total coronary occlusions: Implementing low dose radiation protocols without affecting procedural success rates. Catheter Cardiovasc Interv . 2017; 89(6): 1005–12. https://doi.org/10.1002/ccd.26886
4. Pereg D, Fefer P, Samuel M, Wolff R, Czarnecki A, Deb S, et al. Native coronary artery patency after coronary artery bypass surgery. JACC Cardiovasc Interv. 2014;7(7):761–7.

https://doi.org/10.1016/j.jcin.2014.01.164
5. Fefer P, Knudtson ML, Cheema AN, Galbraith PD, Osherov AB, Yalonetsky S, et al. Current perspectives on coronary chronic total occlusions: the Canadian Multicenter Chronic Total Occlusions Registry. J Am Coll Cardiol. 2012; 59(11): 991–7. https://doi.org/10.1016/j.jacc.2011.12.007
6. Kusu-Orkar TE, Masharani K, Harky A, Muir AD. Redo Coronary Artery Bypass Grafting in the era of Advanced PCI. Braz J Cardiovasc Surg. 2022 Aug 16; 37(4): 546-553. https://doi.org/10.21470/1678-9741-2019-0206.
7. Brilakis ES, O'Donnell CI, Penny W, Armstrong EJ, Tsai T, Maddox TM, et al. Percutaneous coronary intervention in native coronary arteries versus bypass grafts in patients with prior coronary artery bypass graft surgery: Insights from the Veterans Affairs clinical assessment, reporting, and tracking program. JACC Cardiovasc Interv. 2016; 9(9): 884–93. https://doi.org/10.1016/j.jcin.2016.01.034
8. Brilakis ES, Rao SV, Banerjee S, Goldman S, Shunk KA, Holmes DR Jr, et al. Percutaneous coronary intervention in native arteries versus bypass grafts in prior coronary artery bypass grafting patients: a report from the National Cardiovascular Data Registry. JACC Cardiovasc Interv 2011; 4(8): 844–50. https://doi.org/10.1016/j.jcin.2011.03.018
9. Maeremans J, Spratt JC, Knaapen P, Walsh S, Agostoni P, Wilson W, et al. Towards a contemporary, comprehensive scoring system for determining technical outcomes of hybrid percutaneous chronic total occlusion treatment: The RECHARGE score: The RECHARGE score for CTO-PCI. Catheter Cardiovasc Interv 2018; 91(2): 192–202. https://doi.org/10.1002/ccd.27092
10. Tajti P, Karmpaliotis D, Alaswad K, Jaffer FA, Yeh RW, Patel M, et al. The hybrid approach to chronic total occlusion percutaneous coronary intervention. JACC Cardiovasc Interv. 2018;11(14):1325–35. https://doi.org/10.1016/j.jcin.2018.02.036
11. van Veelen A, the PCI, Claessen BEPM, Houterman S, Hoebers LPC, Elias J, et al. Registration Committee of the Netherlands Heart Registration. Incidence and outcomes of chronic total occlusion percutaneous coronary intervention in the Netherlands: data from a nationwide registry. Neth Heart J . 2021;29(1):4–13. Available from: https://doi.org/10.1007/s12471-020-01521-y
12. Shi Y, He S, Luo J, Jian W, Shen X, Liu J. Lesion characteristics and procedural complications of chronic total occlusion percutaneous coronary intervention in patients with prior bypass surgery: A meta-analysis. Clinical Cardiology. 2022 Jan; 45(1): 18-30.
13. Eertmans W, Kayaert P, Bennett J, Ungureanu C, Bataille Y, Saad G, et al. The evolution of the CTO-PCI landscape in Belgium and Luxembourg: a four-year appraisal. Acta Cardiologica. 2021; 76(10): 1043–51 https://doi.org/10.1080/00015385.2020.1801197
14. Lee S-W, Lee PH, Ahn J-M, Park D-W, Yun S-C, Han S, et al. Randomized trial evaluating percutaneous coronary intervention for the treatment of chronic total occlusion: The DECISION-CTO trial. Circulation. 2019; 139(14): 1674–83 https://doi.org/10.1161/circulationaha.118.031313
15. Rigueira J, Aguiar-Ricardo I, Nobre Menezes M, Santos R, Rodrigues T, Cunha N, et al. The CTo-aBCDE score: A new predictor of success in chronic total occlusions. Rev Port Cardiol . 2020;39(10):575–82. https://doi.org/10.1016/j.repc.2020.05.007
16. Muraca I, Carrabba N, Virgili G, Bruscoli F, Migliorini A, Pennesi M, et al. Chronic total occlusion revascularization: A complex piece to "complete" the puzzle. World J Cardiol . 2022;14(1):13–28. https://doi.org/10.4330/wjc.v14.i1.13
17. Potter BJ, Matteau A, Noiseux N, Mansour S. High stakes: CTO-PCI in the post-CABG patient. Can J Cardiol. 2018;34(3):238–40. Available from: https://doi.org/10.1016/j.cjca.2017.12.022
18. Guo L, Lv H, Yin X. Chronic Total Occlusion Percutaneous Coronary Intervention in Patients With Prior Coronary Artery Bypass Graft: Current Evidence and Future Perspectives. Front Cardiovasc Med. 2022 Apr 11;9:753250. https://doi.org/10.3389/fcvm.2022.753250.
19. Hernandez-Suarez DF, Azzalini L, Moroni F, Tinoco de Paula JE, Lamelas P, Campos CM, et al. Outcomes of chronic total occlusion percutaneous coronary intervention in patients with prior coronary artery bypass graft surgery: Insights from the LATAM CTO registry. Catheter Cardiovasc Interv 2022;99(2):245–53. https://doi.org/10.1002/ccd.30041
20. Budassi S, Zivelonghi C, Dens J, Bagnall AJ, Knaapen P, Avran A, et al. Impact of prior coronary artery bypass grafting in patients undergoing chronic total occlusion-percutaneous coronary intervention: procedural and clinical outcomes from the REgistry of Crossboss and Hybrid procedures in FrAnce, the NetheRlands, BelGium, and UnitEd Kingdom (RECHARGE). Catheterization and Cardiovascular Interventions. 2021 Jan 1;97(1):E51-60. https://doi.org/10.1002/ccd.28954
21. Sakakura K, Nakano M, Otsuka F, Yahagi K, Kutys R, Ladich E, et al. Comparison of pathology of chronic total occlusion with and without coronary artery bypass graft. Eur Heart J. 2014;35(25):1683–93. https://doi.org/10.1093/eurheartj/eht422