Original Article

Castle Score Versus J-CTO Score for The Prediction of Technical Success in Chronic Total Occlusion Percutaneous Revascularization

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ABSTRACT

Background: Chronic total occlusions (CTOs) present a significant challenge in percutaneous coronary intervention (PCI). Accurate preprocedural assessment and planning are crucial for the success of these interventions. The J-CTO score has been widely used to predict the success of PCI in CTO cases, but recent developments have introduced the EuroCTO (CASTLE) score, which may offer advantages in complex cases.

Objective: This study aimed to compare the predictive accuracy of the EuroCTO (CASTLE) score with the J-CTO score in determining the success of PCI in CTO cases, with a focus on their utility in preprocedural planning and risk assessment.

Methods: Conducted at a tertiary cardiac care center in Rawalpindi, Pakistan, this analytical cross-sectional study involved 120 patients undergoing PCI for CTO from January 2023 to November 2023. Inclusion criteria were patients aged 18-80 years requiring PCI for CTO, while patients with acute coronary syndromes, pregnant women, or those refusing consent were excluded. Data on clinical, angiographic, and procedural characteristics were systematically recorded. The EuroCTO (CASTLE) and J-CTO scores were calculated based on established algorithms. Technical success was defined as effective revascularization of the CTO lesion with less than 30% residual stenosis and TIMI grade 3 antegrade flow restoration. Statistical analysis was conducted using SPSS 25.

Results: The mean age of the participants was 58.85 ± 11.1 years, with a male predominance (62.5%). Hypertension (67.5%) and hyperlipidemia (78.3%) were common comorbidities. The mean procedural time was 132.42 ± 5.11 minutes, and the mean fluoroscopy time was 41.19 ± 2.41 minutes. The J-CTO and EuroCTO (CASTLE) scores were 2.09 ± 0.70 and 1.91 ± 0.69, respectively. Multivariate logistic regression analysis showed comparable predictive performance between the two scores, with slightly better discriminative ability in complex cases for the EuroCTO (CASTLE) score.

Conclusion: Both the EuroCTO (CASTLE) and J-CTO scores effectively predict the success of PCI in CTO cases, with the EuroCTO (CASTLE) score showing potential advantages in more complex scenarios. These scoring systems are valuable tools for clinicians in preprocedural planning and risk assessment, enhancing the decision-making process in CTO interventions.

Keywords: Chronic Total Occlusion, Percutaneous Coronary Intervention, EuroCTO (CASTLE) Score, J-CTO Score, Cardiology, Preprocedural Planning.

INTRODUCTION

Recent advancements in percutaneous coronary intervention (PCI) for chronic total occlusions (CTOs) have marked a significant milestone in cardiology(1). CTOs, characterized by 100% stenosis with TIMI (Thrombolysis in Myocardial Infarction) grade 0 flow, affect approximately 20% of patients undergoing coronary angiography(2). The absence of detectable blood flow beyond the occlusion site, a hallmark of CTOs, distinguishes them from temporary or acute blockages. These occlusions are prevalent in 30 to 50% of individuals diagnosed with coronary artery disease (CAD), and this prevalence is notably higher in patients with a history of

coronary artery bypass graft (CABG) surgery(4,5,6). The right coronary artery is the most commonly affected vessel in CTOs, accounting for about half of the cases(7). However, only a fraction of patients presenting with ST-elevation myocardial infarction (STEMI) are found to have CTOs, highlighting the variation in prevalence across different clinical contexts(8).

Symptoms of CTOs can range from being asymptomatic to presenting with chest pain or shortness of breath. The past decade has seen significant advancements in techniques and equipment for PCI in CTOs, leading to improved success rates(9,10). Nevertheless, the outcomes of these interventions are influenced by various factors, including lesion complexity, operator expertise, and patient characteristics. The preprocedural preparation, involving an assessment of clinical risk factors and the diagnostic coronary angiogram, is crucial in strategizing the approach for CTO PCI and enhancing the likelihood of successful outcomes(11).

Given the challenges in CTO treatment, it is vital to identify the most predictive scoring system for the technical success of percutaneous revascularization. This study focuses on comparing the Castle Score and the J-CTO Score to determine their efficacy in predicting the success of percutaneous revascularization in CTOs. Such comparative analysis is essential for guiding clinicians towards the most effective treatment strategies, ultimately aiming to improve patient outcomes in the complex field of CTO management.

MATERIAL AND METHODS

The study was an analytical cross-sectional investigation conducted at a tertiary cardiac care center in Rawalpindi, Pakistan. Spanning from January 2023 to November 2023, this research focused on patients who underwent percutaneous coronary intervention (PCI) for chronic total occlusions (CTO). A total of 120 successive CTO cases were examined, forming a part of a specialized CTO program at this center. The inclusion criteria for the study encompassed patients aged between 18 and 80 years, irrespective of gender, all presenting with CTO and requiring percutaneous revascularization. The study excluded patients with acute coronary syndromes or other emergent conditions necessitating different management strategies, pregnant women, and individuals who declined to provide informed consent.

The data collection process involved a systematic documentation of clinical, angiographic, and procedural details of the CTO cases. These details were prospectively recorded in a specialized CTO database. For the purpose of this study, the J-CTO and EuroCTO (CASTLE) scores were calculated in accordance with the algorithms proposed by Morino et al.(12) and Szijgyarto et al.(8), respectively. The focus was particularly on the analytical cross-sectional study analysis of the EuroCTO (CASTLE) score, given its more recent introduction in the field.

Technical success in the context of CTO PCI was defined as effective revascularization of the CTO lesion, resulting in less than 30% residual stenosis in the vessel diameter within the treated segment and the restoration of TIMI grade 3 antegrade flow. The ethical aspect of the study was duly addressed by obtaining informed consent from all participants. The data analysis was conducted using the respective version of SPSS 25, ensuring rigorous statistical evaluation and interpretation of the findings. This approach allowed for a comprehensive assessment of the predictive capabilities of the J-CTO and CASTLE scores in determining the technical success of percutaneous revascularization in CTO cases, thereby contributing valuable insights to the existing literature and practices in cardiac care.

RESULTS

The study meticulously documented the demographics, clinical characteristics, angiographic features, and outcomes of percutaneous coronary intervention (PCI) in patients with chronic total occlusion (CTO), as reflected in various tables.

In the demographic and clinical profile of the enrolled patients (Table 1), the mean age was observed to be 58.85 years with a standard deviation of 11.1 years. The body mass index (BMI) averaged at 29.21 with a standard deviation of 3.65, suggesting a patient population generally in the overweight category. The Canadian Cardiovascular Society (CCS) angina grading and the New York Heart Association (NYHA) functional classifications were also reported, with means of 2.30 (SD: 0.60) and 1.60 (SD: 0.49), respectively. These scores are indicative of the severity of symptoms experienced by the patients. In terms of procedural metrics, the average procedural time for CTO PCI was 132.42 minutes (SD: 5.11), and the fluoroscopy time was 41.19 minutes (SD: 2.41). The mean contrast volume used during the procedures was 265.05 ml (SD: 17.3), and the radiation dose-area product (DAP) was notably high at 22,019.3 mGy (SD: 28,946.6). The number of stents implanted averaged at 2.05 (SD: 0.73) with an overall stent length of 46.29 mm (SD: 0.251). Regarding the prediction scores, the mean J-CTO score was 2.09 (SD: 0.70) and the Euro CTO (CASTLE) score averaged at 1.91 (SD: 0.69).

The clinical characteristics of the patient cohort (Table 2) depicted a predominance of male patients, constituting 62.5% of the sample, with females making up the remaining 37.5%. The prevalence of comorbid conditions was significant, with hypertension being present in 67.5% of the patients, hyperlipidemia in 78.3%, and a history of smoking in 29.2%. Diabetes was noted in 22.5% of

the patients, while 47.5% had a history of myocardial infarction (MI). Prior percutaneous coronary interventions (PCI) and coronary artery bypass grafting (CABG) were reported in 42.5% and 17.5% of the patients, respectively. Additionally, 7.5% had experienced a cerebrovascular accident (CVA), and 8.3% had peripheral vascular disease. Chronic kidney disease was present in 20.0% of the cohort. Assessing the left ventricular systolic function, 60.0% had good function (ejection fraction, EF >50%), 27.5% moderate (EF: 35-50%), and 5.0% severe (EF <35%). Notably, 18.3% of the patients had a history of previous failed target vessel CTO PCI, and severe tortuosity was found in 3.3% of the cases.

Table 1: Demographics and Clinical Characteristics

Variable	Mean ± SD
Age (Years)	58.85 ± 11.1
BMI	29.21 ± 3.65
CCS	2.30 ± 0.60
NYHA	1.60 ± 0.49
Procedural Time (minutes)	132.42 ± 5.11
Fluoroscopy Time (minutes)	41.19 ± 2.41
Contrast Volume (ml)	265.05 ± 17.3
Radiation DAP (mGy)	22,019.3 ± 28,946.6
Number of Implanted Stents	2.05 ± 0.73
Overall Stent Length (mm)	46.29 ± 0.251
J-CTO Score	2.09 ± 0.70
Euro CTO (CASTLE) Score	1.91 ± 0.69

Table 2: Clinical Characteristics of Enrolled Patients

Clinical Characteristic	Frequency	Percentage
Gender: Male	75	62.5%
Gender: Female	45	37.5%
Hypertension	81	67.5%
Hyperlipidaemia	94	78.3%
Smoking	35	29.2%
Diabetes	27	22.5%
Previous MI	57	47.5%
Previous PCI	51	42.5%
Previous CABG	21	17.5%
Previous CVA	9	7.5%
Peripheral Vascular Disease	10	8.3%
Chronic Kidney Disease	24	20.0%
Left Ventricular Systolic Function: Good	72	60.0%
Left Ventricular Systolic Function: Moderate	33	27.5%
Left Ventricular Systolic Function: Severe	6	5.0%
Previous Failed Target Vessel CTO PCI	22	18.3%
Severe Tortuosity	4	3.3%

The angiographic characteristics (Table 3) revealed that the right coronary artery (RCA) was the most common target vessel for CTO, involved in 70.8% of the cases, followed by the left anterior descending (LAD) and left circumflex (LCX) arteries at 22.5% and 6.7%, respectively. The CTO length exceeded 20 mm in 59.2% of the cases. Blunt proximal caps were noted in 42.5% of the cases, and calcification was present in 47.5%, with 19.2% classified as severe. Tortuosity was observed in 23.3% of the lesions, of which 3.3% were severely tortuous.

Table 3: Angiographic Characteristics of Enrolled Cases

Angiographic Characteristic	Frequency	Percentage
Target CTO Vessel: RCA	85	70.8%
Target CTO Vessel: LAD	27	22.5%
Target CTO Vessel: LCX	8	6.7%
CTO Length >20 mm	71	59.2%
Blunt Proximal Cap	51	42.5%
Calcification	57	47.5%
Severe Calcification	23	19.2%
Tortuosity	28	23.3%

Table 4: Multivariate Logistic Regression Analysis for Prediction of CTO PCI Technical Outcome

Variable	OR	P-value
Euro CTO (CASTLE) Score	0.601	0.009
J-CTO Score	0.598	0.008
BMI	0.674	0.007
Chronic Kidney Disease	0.814	0.751
Previous MI	1.158	0.701
Previous PCI	1.012	0.802
Diabetes	1.181	0.710
Peripheral Vascular Disease	1.351	0.420
Target CTO Vessel: LAD	0.345	0.070
Target CTO Vessel: RCA	0.623	0.300
Left Ventricular Function: Good	2.271	0.200
Left Ventricular Function: Moderate	2.441	0.200

The multivariate logistic regression analysis for predicting the technical outcome of CTO PCI (Table 4) demonstrated significant associations with the Euro CTO (CASTLE) score (OR: 0.601, P-value: 0.009) and the J-CTO score (OR: 0.598, P-value: 0.008). Other variables such as BMI (OR: 0.674, P-value: 0.007), and chronic kidney disease (OR: 0.814, P-value: 0.751) were also analyzed. The target CTO vessel, whether LAD (OR: 0.345, P-value: 0.070) or RCA (OR: 0.623, P-value: 0.300), and the left ventricular function, both good (OR: 2.271, P-value: 0.200) and moderate (OR: 2.441, P-value: 0.200), were included in the analysis, providing insights into the factors influencing the success of CTO PCI.

This comprehensive evaluation, spanning demographic details, clinical presentations, angiographic features, and procedural outcomes, offers a robust understanding of the factors influencing the success of PCI in patients with CTO, underpinned by the predictive utility of the J-CTO and Euro CTO (CASTLE) scores.
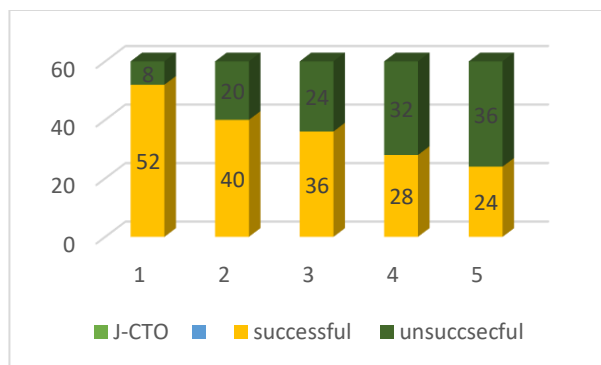

FIG 1: *Success rates of the J-CTO score depending of the different values.*
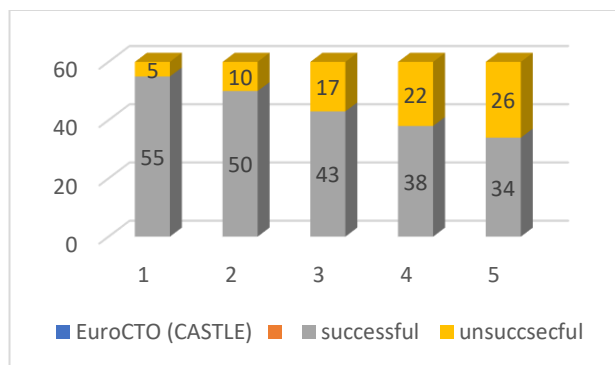

FIG 2: *Success rates of the CASTLE score depending of the different values.*

DISCUSSION

In this study, we undertook a comprehensive analysis to compare the efficacy of the EuroCTO (CASTLE) score and the J-CTO score in predicting the technical success of chronic total occlusion (CTO) percutaneous revascularizations. Our findings indicate that the EuroCTO (CASTLE) score demonstrates a predictive performance comparable to the well-established J-CTO score, a finding that holds significant implications in the field of interventional cardiology (13). The ability to assess case complexity and accurately predict outcomes is invaluable in optimizing CTO percutaneous coronary intervention (PCI) strategies.

One of the primary benefits of these scoring systems is their potential to guide the assessment of the appropriateness of CTO PCI, taking into consideration the overall risk-benefit ratio of the procedure (13). This is particularly crucial in the context of interventional cardiologists, especially those in the early stages of their CTO PCI training. For these practitioners, the scoring systems can aid in selecting less complex cases or in referring more intricate cases to experienced operators or performing them under proctor support. Moreover, the objective quantification of lesion complexity by these scores facilitates meticulous procedural planning, a critical step before embarking on CTO recanalization, benefiting both experienced and less-experienced CTO PCI operators.

While several predictive scoring systems have been developed from registries, these have often been limited by the relatively small number of patients and considerable variability in recanalization techniques, success rates, patient characteristics, case complexity, and operator skills (14-18). This variability has constrained the broader applicability of these scores. The J-CTO score, one of the most widely used scores, was derived from a cohort of 465 patients and primarily focused on the antegrade approach, with a success rate of 48% in guidewire crossing within 30 minutes (14). In contrast, our study, aligning with previous research, consistently observed that higher scores in both J-CTO and CASTLE are associated with decreased success rates in CTO percutaneous revascularization, suggesting that increased complexity correlates with lower likelihoods of procedural success (19, 20).

The EuroCTO (CASTLE) score, in particular, stands out for its development and validation on a large cohort of over 20,000 cases, encompassing a broad spectrum of contemporary CTO PCI techniques and equipment. This large cohort, featuring a consistent distribution of operator experience and including a wide range of CTO PCI techniques, potentially enhances the score's accuracy in predicting outcomes for challenging CTO PCIs. Our findings suggest that the EuroCTO (CASTLE) score may offer a slight edge over the J-CTO score in more complex cases, which is crucial for decision-making and optimizing intervention success.

The study also highlights that higher grades in both the Euro CTO (CASTLE) and J-CTO scores correlate with increased levels of procedural efficiency metrics, such as radiation exposure, contrast volumes, procedural time, and fluoroscopy time (21, 22). This correlation underscores the increasing demand for resources and time as case complexity escalates, emphasizing the need for adequate preparation and resource allocation for higher-complexity procedures.

Notwithstanding these insights, our study has its limitations. The single-center nature and the specific patient population may limit the generalizability of our findings. Additionally, the retrospective design could introduce selection bias. Future studies could benefit from a multicentric approach, encompassing a more diverse patient population and potentially incorporating a prospective study design.

CONCLUSION

Our research contributes to the growing body of evidence supporting the use of predictive scoring systems in CTO PCI. These scores not only forecast technical success but also offer estimations of operation and lesion complexity, assess efficiency measures, and aid in angiographic data analysis. They provide a comprehensive and practical approach to clinical decision-making in CTO PCI. The decision to proceed with CTO revascularization should be underpinned by a thorough risk-benefit analysis and informed by open communication with the patient and the Heart Team, considering the heightened risk of complications associated with these complex procedures.

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