



Predicting procedure success in chronic total occlusion using machine learning methods

ML prediction of CTO PCI success

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Abstract

Aim: Chronic total occlusion (CTO) in coronary arteries presents a significant challenge in interventional cardiology, particularly due to the high rates of procedural failure. CTO-PCI is an established revascularization strategy for selected patients, though procedural success varies. This study investigates the predictive accuracy of various machine learning (ML) algorithms in assessing procedural success in CTO cases.

Methods: Data were collected from 112 patients with CTO who underwent PCI. Sociodemographic, clinical, and laboratory variables, including hypertension, monocyte count, cholesterol levels, LDL-C, uric acid, CRP, and the Naples prognostic score (NPS), were included. Six ML models, Bayesian neural network (BNN), Decision Tree, logistic regression (LR), support vector machine, Naive Bayes, and k-nearest neighbor, were trained using MATLAB software, with 80% of the data for training and 20% for testing.

Results: LR demonstrated the highest accuracy, with a 91.9% prediction rate for procedural success, followed by k-nearest neighbor and BNN. Hypertension and a high NPS were associated with increased procedural failure, while favorable lipid profiles and low CRP were positive predictors of success.

Conclusion: ML models, particularly LR, show potential for predicting procedural outcomes in CTO interventions, offering a valuable tool for pre-procedural assessment. These findings support the integration of ML-based decision-making systems in clinical settings to enhance planning and optimize patient outcomes in high-risk CTO cases.

Keywords

chronic total occlusion, machine learning, logistic regression, Naples prognostic score

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Introduction

Coronary artery disease (CAD) is a leading cause of mortality and morbidity worldwide. In 15% of patients with CAD, at least one coronary artery with chronic total occlusion (CTO) is present. Revascularization of CTO through percutaneous coronary intervention (PCI) requires meticulous procedural planning and experienced physicians to ensure minimal complications and high success rates.¹ CTO was defined as a coronary occlusion with TIMI 0 flow of presumed duration greater than or equal to 3 months. This condition is often caused by the buildup of plaque (atherosclerosis) within the coronary arteries, leading to restricted or completely obstructed blood flow to the heart muscle. The treatment of CTO has become widespread with advances in percutaneous transluminal coronary angioplasty (PTCA) technology. It is reported that approximately 15-30% of patients undergoing PTCA have CTO.² In the literature, factors such as a history of coronary artery bypass grafting (CABG) and PTCA, a decrease of over 40% in ejection fraction (EF), involvement of the right coronary artery (RCA) and left anterior descending coronary artery (LAD), and multi-vessel disease are associated with lower procedural success in CTO.³ Procedural success in the context of CTO interventions refers to the successful revascularization of the occluded coronary artery, resulting in restored blood flow without significant complications. Achieving procedural success is associated with improved patient outcomes, including relief from symptoms such as chest pain and shortness of breath, as well as a reduction in the risk of future cardiac events.⁴ This study aims to predict the procedural success in patients with CTO who underwent PTCA by using machine learning (ML) methods based on patients' clinical and vascular characteristics.

Materials and Methods

Study Design

This study was conducted in accordance with the Declaration of Helsinki, originally dated 1964 and revised in October 2024. Verbal and written informed consent were obtained from participants. This study was based on data collected from patients who underwent procedures in the Angiography Unit at Adiyaman University Training and Research Hospital. For patients diagnosed with CTO by PTCA, myocardial perfusion scintigraphy (MPS) was subsequently performed. A second PTCA procedure was applied to CTO patients in whom ischemia was detected on MPS. The relationship between patients' clinical data and procedural success was then predicted using ML methods.

Inclusion and Exclusion Criteria

Eligible patients met the following inclusion criteria: a diagnosis of chronic total occlusion (CTO) in at least one coronary artery confirmed by angiographic evidence, age between 18 and 80 years, suitability for percutaneous coronary intervention (PCI) as the treatment strategy for CTO, and provision of written informed consent to participate in the study.

Patients were excluded if they had any of the following: a history of acute myocardial infarction within the previous 30 days; severe comorbid conditions, such as advanced renal failure (creatinine > 2.5 mg/dL) or severe liver dysfunction, that could interfere with the procedure or with undergoing PCI; active infection, including sepsis, requiring immediate medical treatment; ineligibility for PCI because of anatomical factors, such as severe coronary calcification; a requirement for coronary artery bypass grafting instead of PCI; pregnancy or breastfeeding; or severe allergy to contrast agents or medications used during PCI.

These criteria were applied to ensure that only patients who were appropriate and safe candidates for PCI were included and to minimize potential confounding factors and complications that could affect the study results.

Naples Prognostic Score

The Naples prognostic score (NPS) is based on four parameters: serum albumin and total cholesterol levels, neutrophil-to-lymphocyte ratio (NLR), and lymphocyte-to-monocyte ratio (LMR). For albumin, a concentration below 4 g/dL receives a score of 1, whereas a level of 4 g/dL or above is scored as 0. For cholesterol, values under 180 mg/dL are assigned a score of 1, and those of 180 mg/dL or more receive a score of 0. An NLR of 2.96 or higher is scored as 1, while values below this threshold are scored as 0. Similarly, an LMR lower than 4.44 is given a score of 1, whereas an LMR of 4.44 or above is scored as 0. The NPS is the total of these four scores. A higher NPS typically signifies a poorer prognosis and indicates a need for closer patient monitoring. This scoring system is a valuable tool for evaluating a patient's nutritional status, inflammatory response, and immune function, supporting the development of appropriate treatment plans.⁵

A total of 36 variables, including sociodemographic data, laboratory values, comorbidities, and vascular characteristics, were included in the study. Among these variables, hypertension, monocyte count, total cholesterol, LDL, uric acid, CRP, MPV, and NPS were used in ML methods to predict procedural success.

The schematic representation of the network configuration utilized in this research is illustrated in Figure 1. A concise representation of the DT architecture utilized in this investigation is presented in Figure 2. NPS, mean platelet volume (MPV), and serum uric acid level were used in DT to predict procedural success in CTO.

Of the 36 variables included in the study, 8 exhibited an absolute correlation coefficient greater than 0.15 with procedural success, as detailed in Table 1.

Table 1. List Of Inputs Used For Predictions

Predictors	Values range
HT	[0-1]
Monocyte	[0.00-1.60]
Total-C	[109-307]
LDL-C	[31-199]
Uric acid	[2.30-9.10]
CRP	[0.20-0.70]
MPV	[4.67-13.59]
NPS	[0-4]

HT, Hypertension; Total-C, Total Cholesterol; LDL-C, Low density lipoprotein cholesterol; CRP, C-reactive protein; MPV, Mean platelet volume; NPS, Naples prognostic score

Ethical Approval

This study was approved by the Ethics Committee of Adiyaman University, Faculty of Medicine (Date: 19.11.2024, Decision No: 2024/9-4).

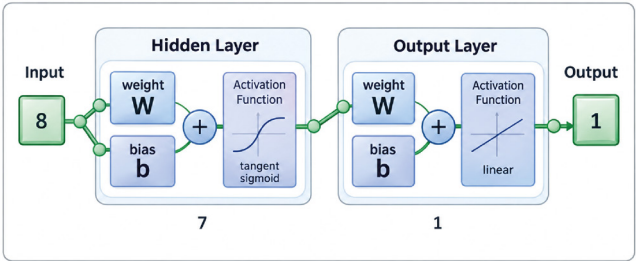


Figure 1. The Architecture of the Neural Network

Statistical Analysis

Pearson's correlation method was used to evaluate the relationship between the variables and procedural success. Variables with an absolute correlation coefficient above 0.15 were included in further analysis. Bayesian neural network, decision tree, logistic regression, linear support vector machine, Naive Bayes, and k-nearest neighbor methods were used for prediction. Of the dataset, 80% (n = 90) was used for training and validation and 20% (n = 22) for testing. The analyses were performed using MATLAB 2024a.

Reporting Guidelines

This study was reported in accordance with the STROBE guideline.

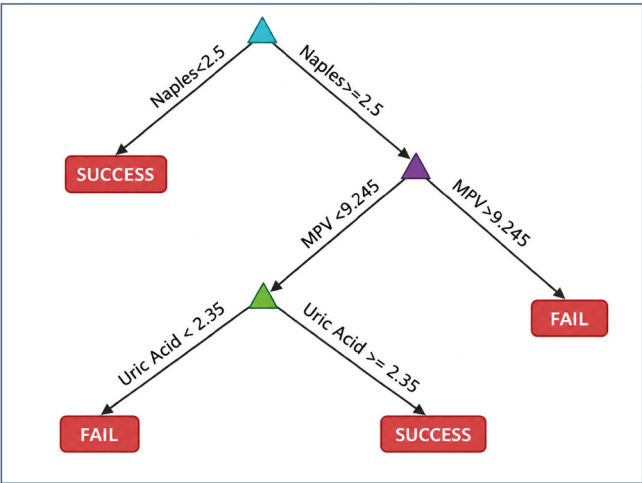


Figure 2. The Architecture of DT Used in this Research

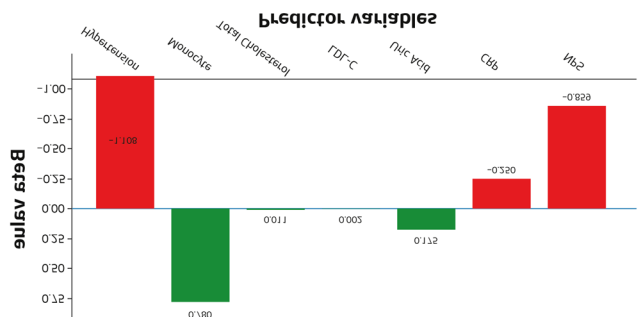


Figure 3. Beta Values of Predictors for Procedure Success in LR

Results

The findings indicate that all evaluated methodologies attained a predictive accuracy exceeding 80% utilizing the selected predictors. Among these, the LR algorithm demonstrated superior performance, achieving a validation accuracy of 81.1%. Furthermore, the LR approach exhibited exceptional efficacy in test predictions, attaining an accuracy rate of 91.9%.

In LR, hypertension, monocyte count, total cholesterol, LDL-C, uric acid, CRP, and NPS were used to predict procedural success. The β values were as follows: hypertension, $\beta = -1.108$; monocyte, $\beta = 0.780$; total cholesterol, $\beta = 0.011$; LDL-C, $\beta = 0.002$; uric acid, $\beta = 0.175$; CRP, $\beta = -0.250$; and NPS, $\beta = -0.859$ (Figure 3). The NPS value was statistically significantly higher in CTO patients who did not undergo recanalization after PTCA. Lymphocyte value and total cholesterol were statistically significantly lower in CTO patients who did not undergo recanalization with the PTCA procedure ($P < .001$ and $P = .004$, respectively).

The detailed data are provided in Supplementary Tables 1-3.

Discussion

In this study, it was demonstrated that PTCA procedural success in CTO cases could be predicted using ML methods based on pre-procedural clinical and biochemical data. The findings indicate that data obtained before the procedure can predict procedural success with an accuracy rate of 91.9%. This result highlights the potential of artificial intelligence and ML-based decision support systems in CTO management and could be important for pre-emptive intervention planning in clinical applications.

The challenges in treating CTOs and the long-term poor prognosis of these patients emphasize the need for optimizing clinical decision-making processes. Existing studies in the literature indicate that CTO patients are at higher risk for major adverse cardiac events such as cardiovascular death, myocardial infarction (MI), and heart failure.⁶ The initial study showed that CTO revascularization could significantly reduce these risks, particularly revealing that non-revascularized CTO patients are more prone to cardiovascular events.⁷ Our study offers an important tool for predicting procedural success in CTO patients and determining which patients may benefit most from PTCA.

A meta-analysis by Patel et al., which included data from 65 studies, reported an overall success rate of 77% for CTO-PCI procedures with low procedural complications.⁸ Our study's success rate of 77.7% aligns with Patel's findings⁸ and confirms that the success rates have increased with newly developed devices and methods in recent years. Specifically, the use of new tools, such as guide wires, microcatheters, and re-entry devices, has reduced the difficulty of CTO-PCI and improved success rates.⁹

Lee et al.¹⁰ emphasized that successful procedures in CTO-PCI are crucial for reducing serious complications and managing long-term mortality despite the risk of periprocedural myocardial injury. In our study, a high NPS and hypertension before the procedure were identified as indicators associated with procedural failure. These findings suggest that pre-procedural risk factors should be considered in procedural planning. Additionally, making predictions through ML in the presence of such risk factors can help clinicians establish risk management strategies in advance.

Noguchi et al.¹¹ showed that the success of CTO-PCI could be limited by factors such as calcification, occlusion length, and multi-vessel disease. In their study, the presence of calcified lesions emerged as the most common reason for procedural failure. In our study, a high NPS was observed to increase the risk of procedural failure. A high NPS, reflecting inflammatory status and indicators of poor nutrition, may negatively affect outcomes. A high Naples prognostic score also indicates elevated levels of chronic inflammation and an increased neutrophil-to-lymphocyte ratio. This inflammatory state weakens the vessel walls, raising the risk of re-occlusion and increasing the likelihood of post-procedural complications.¹² In previous studies, high NPS scores have been found to be predictive of long-term mortality in ST-elevation MI,¹³ all-cause mortality in decompensated heart failure,¹⁴ SYnergy between PCI with TAXUS and Cardiac Surgery (SYNTAX) score in ST-elevation MI,¹⁵ and mortality in aortic valve replacement.¹⁶ However, as in our study, no study using NPS to evaluate procedural success in CTO has been found in the literature.

Cuevas et al. demonstrated that repeat attempts after an initial failed CTO revascularization could improve success rates. Their study highlighted that experienced operators and intravascular ultrasound guidance are key determinants of procedural success.¹⁷ Our study, while evaluating the predictability of success rates before the procedure using ML, suggests that such planning tools

could be particularly useful in managing high-risk cases. Following unsuccessful initial attempts in CTO, ML predictions could guide clinicians in strategizing subsequent interventions.

Lingman et al.¹⁸ emphasized the adverse effects of chronic conditions, such as hypertension and diabetes, on post-PCI outcomes. In our study, hypertension was found to have a strong association with procedural failure in CTO patients. Consistent with the findings of Lingman et al., our study underscores the importance of personalized treatment strategies in CTO management and demonstrates that early identification of high-risk patients can be a determining factor for procedural success. Hypertension is known to increase the long-term risk of MI, stroke, and heart failure.¹⁹ Hypertension leads to hardening and calcification of the arteries, reducing vascular elasticity. This makes it more challenging to open completely blocked arteries, such as in CTO, because it becomes more difficult to effectively place balloons and stents in hardened vessels.²⁰ Hypertension also disrupts microvascular structures, reducing blood flow to the heart and causing myocardial damage. Microvascular circulation disorders can negatively affect the success of revascularization procedures, as adequate blood flow to the heart muscle may not be achieved post-procedure.²¹ Hypertension can induce a chronic inflammatory state, and elevated inflammation levels can lead to re-occlusion of vessels during procedures and complicate the healing process, thereby increasing failure rates in CTO revascularization.²² Patients with hypertension often have more complex vascular diseases, with multi-vessel involvement and lesions, which prolong the procedure time, increase complication risks, and reduce the chances of success. In hypertensive patients, there is also a higher risk of sudden blood pressure spikes or bleeding complications during the procedure.²³ Such complications can make it challenging to complete the procedure effectively.

Limitations

This study has certain limitations. In this study, we focused on clinical and biochemical predictors. However, we acknowledge that procedural and anatomical variables, such as lesion length, morphology, calcification degree, vessel diameter, stump type, and cap ambiguity, are crucial for predicting CTO-PCI success. Additionally, operator experience and the use of advanced tools can also influence outcomes. Future studies incorporating these variables would likely improve the model's predictive accuracy and provide a more comprehensive assessment of CTO-PCI outcomes. External validation was not performed, which limits the generalizability of the models. Future studies should include external validation using separate datasets to assess the robustness and applicability of the models in different clinical settings.

Conclusion

One of the most significant findings of this study is the high accuracy rates achieved using different ML models. The best results were obtained with the LR model, with an accuracy of 91.9%. This suggests that statistical modeling and ML approaches can be effective in CTO management. The fact that factors such as hypertension, monocyte count, total cholesterol, and LDL levels are among the important parameters affecting procedural success highlights the need for careful consideration of these factors in clinical evaluations.

Declarations

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent

Verbal and written informed consent was obtained from participants.

Data Availability

The datasets used and/or analyzed during the current study are not publicly available due to patient privacy reasons, but are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

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None.

Author Contributions (CRediT Taxonomy)

Conceptualization: V.K., S.M., M.B., S.A., S.A.
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AI Usage Disclosure

The authors declare that no AI-assisted technologies were used.

Abbreviations

BNN: Bayesian neural network
CABG: Coronary artery bypass grafting
CAD: Coronary artery disease
CRP: C-reactive protein
CTO: Chronic total occlusion
DT: Decision tree
EF: Ejection fraction
LAD: Left anterior descending coronary artery
LDL: Low-density lipoprotein cholesterol
LMR: Lymphocyte-to-monocyte ratio
LR: Logistic regression
MI: Myocardial infarction
ML: Machine learning
MPS: Myocardial perfusion scintigraphy
MPV: Mean platelet volume
NB: Naive bayes
NPS: Naples prognostic score
PCI: Percutaneous coronary intervention
PTCA: Percutaneous transluminal coronary angioplasty
RCA: Right coronary artery

References

1. Kucukseymen S, Iannaccone M, Grantham JA, et al. Association of successful percutaneous revascularization of chronic total occlusions with quality of life: a systematic review and meta-analysis. JAMA Netw Open. 2023;6(7):e2324522. doi:10.1001/jamanetworkopen.2023.24522

2. Fefer P, Knudtson ML, Cheema AN, et al. Current perspectives on coronary chronic total occlusions: the Canadian multicenter chronic total occlusions registry. J Am Coll Cardiol. 2012;59(11):991-997. doi:10.1016/j.jacc.2011.12.007

3. Galassi AR, Vadalà G, Werner GS, et al. Evaluation and management of patients with coronary chronic total occlusions considered for revascularisation. A clinical consensus statement of the European Association of Percutaneous Cardiovascular Interventions (EAPCI) of the ESC, the European Association of Cardiovascular Imaging (EACVI) of the ESC, and the ESC Working Group on Cardiovascular Surgery. EuroIntervention. 2024;20(3):e174-e184. doi:10.4244/eij-d-23-00749

4. Değirmenci H, Bakırcı EM, Hamur H. Kronik Total oklüzyona güncel yaklaşım [Current to

approach chronic total occlusion]. *MN Kardiyoloji*. 2015;22(3):150-158.

5. Uysal OK, Ozdogru D, Yildirim A, Ozturk I, Tras G, Arlier Z. The prognostic value of a Naples score in determining in-hospital mortality in patients with acute ischemic stroke undergoing endovascular treatment. *J Clin Med*. 2024;13(21):6434. doi:10.3390/jcm13216434
6. Sutton NR, Bates ER. Balancing the benefits, risks, and costs of chronic total occlusion percutaneous coronary intervention. *Circ Cardiovasc Interv*. 2019;12(3):e007809. doi:10.1161/circinterventions.119.007809
7. Azzalini L, Poletti E, Ayoub M, et al. Coronary artery perforation during chronic total occlusion percutaneous coronary intervention: epidemiology, mechanisms, management, and outcomes. *EuroIntervention*. 2019;15(9):e804-e811. doi:10.4244/eij-d-19-00282
8. Patel VG, Brayton KM, Tamayo A, et al. Angiographic success and procedural complications in patients undergoing percutaneous coronary chronic total occlusion interventions: a weighted meta-analysis of 18,061 patients from 65 studies. *JACC Cardiovasc Interv*. 2013;6(2):128-136. doi:10.1016/j.jcin.2012.10.011
9. Galassi AR, Tomasello SD, Reifart N, et al. In-hospital outcomes of percutaneous coronary intervention in patients with chronic total occlusion: insights from the ERCTO (European Registry of Chronic Total Occlusion) registry. *EuroIntervention*. 2011;7(4):472-479. doi:10.4244/eijv7i4a77
10. Lee SW, Lee PH, Kang SH, et al. Determinants and prognostic significance of periprocedural myocardial injury in patients with successful percutaneous chronic total occlusion interventions. *JACC Cardiovasc Interv*. 2016;9(21):2220-2228. doi:10.1016/j.jcin.2016.08.005
11. Noguchi T, Miyazaki MD S, Morii I, Daikoku S, Goto Y, Nonogi H. Percutaneous transluminal coronary angioplasty of chronic total occlusions. Determinants of primary success and long-term clinical outcome. *Catheter Cardiovasc Interv*. 2000;49(3):258-264. doi:10.1002/(sici)1522-726x(200003)49:3<258::aid-cc.2-l
12. Ozkan E, Erdogan A, Karagoz A, Tanboğa İH. Comparison of systemic immune-inflammation index and Naples prognostic score for prediction coronary artery severity patients undergoing coronary computed tomographic angiography. *Angiology*. 2024;75(1):62-71. doi:10.1177/00033197231170979
13. Şaylık F, Çınar T, Selçuk M, Akbulut T, Hayiroğlu Mİ, Tanboğa İH. Evaluation of Naples score for long-term mortality in patients with ST-segment elevation myocardial infarction undergoing primary percutaneous coronary intervention. *Angiology*. 2024;75(8):725-733. doi:10.1177/00033197231170982
14. Erdogan A, Genc O, Inan D, et al. Impact of Naples prognostic score on midterm all-cause mortality in patients with decompensated heart failure. *Biomark Med*. 2023;17(4):219-230. doi:10.2217/bmm-2022-0689
15. Oner E, Kahraman S, Agus HZ, et al. Naples score is associated with SYNTAX Score in patients with ST-segment elevation myocardial infarction. *Coron Artery Dis*. 2023;34(7):504-509. doi:10.1097/mca.0000000000001278
16. Erdoğan O, Erdoğan T, Paç C, Gürbak İ, Ertürk M. Naples prognostic score as a predictor of mortality in surgical aortic valve replacement. *Biomark Med*. 2024;18(15-16):675-683. doi:10.1080/17520363.2024.2389035
17. Cuevas C, Ryan N, Quirós A, et al. Determinants of percutaneous coronary intervention success in repeat chronic total occlusion procedures following an initial failed attempt. *World J Cardiol*. 2017;9(4):355-362. doi:10.4330/wjc.v9.i4.355
18. Lingman M, Albertsson P, Herlitz J, Bergfeldt L, Lagerqvist B. The impact of hypertension and diabetes on outcome in patients undergoing percutaneous coronary intervention. *Am J Med*. 2011;124(3):265-275. doi:10.1016/j.amjmed.2010.09.015
19. Flack JM, Peters R, Shafi T, Alrefai H, Nasser SA, Crook E. Prevention of hypertension and its complications: theoretical basis and guidelines for treatment. *J Am Soc Nephrol*. 2003;14(7 Suppl 2):S92-S98. doi:10.1097/01.asn.0000070142.14843.8e
20. Berry C, Brosnan MJ, Fennell J, Hamilton CA, Dominiczak AF. Oxidative stress and vascular damage in hypertension. *Curr Opin Nephrol Hypertens*. 2001;10(2):247-255. doi:10.1097/00041552-200103000-00014
21. Picariello C, Lazzeri C, Attanà P, Chiostrì M, Gensini GF, Valente S. The impact of hypertension on patients with acute coronary syndromes. *Int J Hypertens*. 2011;2011:563657. doi:10.4061/2011/563657
22. Boos CJ, Lip GY. Is hypertension an inflammatory process? *Curr Pharm Des*. 2006;12(13):1623-1635. doi:10.2174/138161206776843313
23. Saluveer O, Redfors B, Angerås O, et al. Hypertension is associated with increased mortality in patients with ischaemic heart disease after revascularization with percutaneous coronary intervention - a report from SCAAR. *Blood Press*. 2017;26(3):166-173. doi:10.1080/08037051.2016.1270162

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