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Original Article

Prediction Score of Antegrade Chronic Total Occlusion Percutaneous Coronary Intervention Success in Dr. Kariadi Central General Hospital Semarang

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Abstract

Background : Lesion characteristics of chronic total occlusion (CTO) are predictors of percutaneous coronary intervention (PCI) success. A prediction score consist of these predictors can help CTO-PCI operators. Various prediction score had been established but none had been established in Indonesian population.
Methods : This observational cohort study was performed in patients underwent native vessel CTO-PCI in Dr. Kariadi Hospital during 2018. Target vessels, ostial lesion, blunt stump, calcification, long lesion, bending, side branch, bridging collateral, and retrograde collateral were angiographic variables proposed to be predictors of CTO-PCI success. All of the variables were quantitatively assessed by two observers. Bivariate and multivariate analysis used to identify independent predictors of CTO-PCI success and to establish a scoring model.
Results : A total 200 patients underwent CTO-PCI procedures were included to this study. All of the procedures used antegrade approach.The prediction score established as follows: bending (1 point), calcification (2 point), blunt stump (3 point), long lesion (1 point), and poor retrograde collateral filling (2 point). Total score ranged from 0 to 9 with decreased probability of success from 92.3% to 0.5%. Score value ≥3 categorized as difficult lesion with higher risk to failure compared to score value <3 (OR 15.4; p<0.001). The score model had good calibration and discrimination in predict CTO-PCI success (AUC 0.88; p<0.001).
Conclusion : Bending, calcification, blunt stump, long lesion, and poor retrograde collateral were predictors of CTO-PCI success. The score consist of these variables could predict antegrade CTO-PCI success.

Keywords : chronic total occlusion; percutaneous coronary intervention; success; prediction score

INTRODUCTION

Percutaneous coronary intervention (PCI) of chronic total occlusions (CTO) can be challenging with variable success rates.[1–3] Werner *et al*. found the significant improvement of the health status in CTO-PCI patients who had successful revascularization followed by stents implantation.[4] Success of CTO-PCI depend on patient and lesion characteristics, the availability of equipments, techniques, and operator experience.[5–8] The presence of lesion characterisctis such as target vessel, ostial lesion, calcification, blunt stump, bending, brigding and retrograde collaterals are known as predictor of CTO-PCI success. Accurate pre-procedural assessment of lesion complexity can help pre-procedural planning. The presence of prediction score can provide objective tool to asses lesion complexity in order to improve procedural success.[9]

The first prediction score established was the Japan–CTO (JCTO) score.[6] The accuracy of the J-CTO score for predicting final CTO-PCI success in contemporary practice has been questioned, as it was developed to predict the likelihood of successful antegrade guidewire crossing rather than final revascularization success.[10–12] Attempts to develop other scores have been made. The differences of CTO-PCI settings had consequences that scoring system established from one centre had lower performance when applied in other center. The prediction scores should ideally be used for estimating success in patients and operators similar to the ones used for their development.[9] None of these prediction score has been established in Indonesian or South East Asia population. This study aimed to establish a prediction score of CTO-PCI revascularization success until stent implantation in Indonesian population especially in Dr. Kariadi Hospital population. Target vessel, ostial lesion, calcification, blunt stump, bending, brigding and retrograde collaterals were proposed to be the independent predictors of CTO-PCI success.

METHODS

Study design and patient population

The study was a cohort retrospective analysis of 200 consecutive patients treated with PCI for CTO of native coronary arteries during Januari 2018 to Januari 2019 in cathetherization laboratory of Dr. Kariadi Hospital. Thenon–native vessels CTOs i.e in bypass graft, in stent restenotic, and in side branch were excluded from the study. The study protocol was approved by the local ethics committee.

Definitions

A CTO was defined as a native coronary artery occlusion without antegrade filling of the distal vessel other than via collateral. The Thrombolysis in Myocardial Infarction (TIMI) antegrade flow equals to zero. The duration of the occlusion had to be more than 3 months, as estimated from the onset of clinical events including myocardial infarction (MI), sudden onset of worsening of chest symptoms, or evidenced by prior angiogram. When the duration of the occlusion was uncertain and the investigators had no clear evidence that it was <3 months, the patient was included in the analysis.[13]

Ostial location was defined as CTO lesion within 3 mm from the origin of the target vessel. The occlusion length was measured based on shoulder to shoulder distance. Lession of ≥20 mm classified as long lession. Presence of calcification in the CTO segment was defined if the lesion had visible densitiesbefore contrast injection. Bending was defined as a bend ≥45° within the CTO body. The lesion was classified as blunt stump type if the occluded segment did not end in the shape of a funnel. Side branch was defined as the presence of side branch in the entry point of the occlusion. Bridging collateral was defined as the presence of antegrade collateral within the same coronary vessel. The measurement of the degree of retrograde collateral supply was performed using a collateral grading system according to the Rentrop classification. Rentrop grade 0 and 1 was classified as poor retrograde collateral filling. Success of CTO-PCI was defined as successful CTO revascularization with achievement of <20% residual diameter stenosis within the stented segment and restoration of TIMI grade 3 antegrade flow. The outcome of CTO-PCI procedures other than this definition was classified as failed CTO-PCI. All of these angiographic variables were quantitatively assessedby two observers using the RadiAnt DICOM Viewer 4.0.3 software package. Intraobserver and interobserver variability were measured using Kappa tests.

Statistical analysis

Clinical, angiographic, and procedural data were analyzed using descriptive statistics. Numerical values were expressed as mean ± standard deviation (normally distributed data) or median and interquartile range (non-normally distributed data) and compared using independent student's t–test or Mann–Whitney U test, as appropriate. Categorical variables were expressed as frequencies or percentages andcompared using chi square or fisher exact test, as appropriate. Univariate analysis were performed to identify angiographic parameters associated with CTO-PCI success. Variables with p value < 0.25 were entered into backward logistic regression analysis. The p value threshold were set at 0.05 to identify independent predictors of PCI success. Independent predictors were incorporated in the final model according to β–coefficient and standard error derived from the last steps of multivariate analysis. The calibration of the score was assessed using

Hosmer–Lemeshow statistic. The discriminatory performance of the model was validated using the receiver-operator characteristics (ROC) curves and the calculated area-under-the-curve (AUC). Statistical analysis were performed with SPSS version 22.0 (IBM corporation).

RESULTS

Baseline population and procedural outcomes

The study consisted of 200 native CTO PCI procedures using antegrade CTO-PCI approach. Procedural success was achieved in 155 (75.5%) of 200 procedures. Mean age was 57.5 ± 8.3years and most of the patients were men (92%). There were no difference of patients clinical characteristics between the success and failed groups. The most common CTO-PCI target vessel was the left anterior descending artery (48.5%), followed by the right coronary artery (40%), and left circumflex artery (11.5%).(Table 1).

Score derivation

Compared with the success procedures, the failed ones were more likely to have blunt stump (69.4% vs 13.9%; p<0.001), bending (14.3% vs 1.3%; p=0.001), long lession (36.7% vs 7.9%; p<0.001); calcification (32.7% vs 9.3%;

TABEL 1
Baseline characteristics

Variables	All subjects (n=200)	Success CTO–PCI (n=151)	Failed CTO–PCI (n=49)	p***
Clinical characteristics				
Age (year)*	57.52 ± 8.31	57.62 ± 8.43	57.20 ± 8.05	0.767
Male sex**	184 (92.0%)	137 (90.7%)	47 (95.9%)	0.199
Overweight–obese BMI**	144 (72.0%)	104 (68.9%)	40 (81.6%)	0.084
Diagnosed as stable angina**	97 (48.5%)	74 (49.0%)	23 (46.9%)	0.801
Diagnosed as heart failure**	78 (39.0%)	60 (39.7%)	18 (36.7%)	0.708
Diabetes Mellitus**	81 (40.5%)	62 (41.1%)	19 (38.8%)	0.777
Hypertension**	109 (54.5%)	83 (54.9%)	26 (53.1%)	0.816
Dyslipidemia**	101 (50.5%)	78 (51.7%)	23 (46.9%)	0.566
Smoker**	110 (55.0%)	81 (53.6%)	29 (59.2%)	0.498
Family history of CAD**	42 (21.0%)	34 (22.5%)	8 (16.3%)	0.355
Creatinine serum level (mg/dl)*	1.34 ± 1.19	1.36 ± 1.37	1.29 ± 0.3	0.644
Lesion characteristics				
Previous failed attempts**	7 (3.5%)	3 (1.9%)	4 (8.2%)	0.063
CAD3VD**	129 (64.5%)	96 (63.6%)	33 (67.3%)	0.632
Target vessel				
LAD**	97 (48.5%)	69 (45.7%)	28 (57.1%)	0.164
LCX**	23 (11.5%)	20 (13.2%)	3 (6.1%)	0.174
RCA**	80 (40.0%)	62 (41.1%)	18 (36.7%)	0.591
Ostial lesion**	2 (1.0%)	1 (0.6%)	1 (2.0%)	0.431
Side branch**	66 (33.0%)	43 (28.5%)	23 (46.9%)	0.017
Bending**	9 (4.5%)	2 (1.3%)	7 (14.3%)	0.001
Calcification**	30 (15.0%)	14 (9.3%)	16 (32.7%)	0.000
Blunt stump**	55 (27.5%)	21(13.9%)	34 (69.4%)	0.000
Long lession**	30 (15.0%)	12 (7.9%)	18 (36.7%)	0.000
Bridging collateral**	160 (80.0%)	126 (83.4%)	34 (69.4%)	0.033
Poor retrograde collateral filling**	14 (7.0%)	1 (0.6%)	13 (26.5%)	0.000

Note : *Mean ± SD; Median (min–max), ** n (%), *** signification difference between success and failed CTO–PCI groups

TABEL 2
Multivariate analysis

Variables	OR	95%CI (min–max)	*p*
Poor retrograde collateral filling	44.313	4.368 – 449.650	0.001
Blunt stump	11.530	4.620 – 28.774	0.000
Bending	7.002	0.818 – 59.907	0.076
Calcification	6.274	2.144 – 18.361	0.001
Long lesion	3.612	1.123 – 11.611	0.031

TABEL 3
The prediction score of CTO–PCI success

Variables	Score
Blunt stump	3
Calcification	2
Poor retrograde collateral filling	2
Long lesion	1
Bending	1

p<0.001), side branch (46.9% vs 28.5%; p=0.017), poor retrograde collateral filling (26.5% vs 0.6%; p<0.001), and less likely to have bridging collateral that help visualization of distal lesion (69.4% vs 83.4%; p=0.033). These variables were analyzed multivariately using a backward stepwise approach. Five parameters remained independently associated with procedural success as follow: long lesion (OR: 3.61; 95% confidence interval (CI): 1.12–11.61; p=0.031), calcification (OR: 6.27; 95% CI: 2.14–18.36; p=0.001), bending (OR: 7.0; 95% CI: 0.82–59.91; p=0.076), blunt stump (OR: 11.53; 95% CI: 4.62–28.77; p<0.001), and poor retrograde collateral filling (OR:44.31; 95% CI: 4.37–449.65; p=0.001) (Table 2). These independent predictors were scored according to the corresponding β-coefficient and standard error on the last step of backward stepwise logistic regression (Table 3).

The score ranged from 0 to 9 with decreased likelihood of succes from 95.3% in score 0 to 0.45% in score 9 (Figure 1). The cut–off point was ≥3 with sensitivity 73.5%; spesificity 84.8%; and positive predictive value 61.0%. Total score ≥3 were categorized as difficult lesion with probability to success ≤55.3% and had 15.4 times probability to failure compared to total score <3 (p<0.001). The model provided good callibration as indicated by the non significant Hosmer–Lemeshow goodness of fit (p=1.0). A receiver operating characteristic curve analysis of the score demonstated good discrimination in predicting CTO-PCI success (AUC ROC 0.88; 95% CI:0.82–0.94, p<0.001) (Figure 2).

DISCUSSION

Our prediction score developed from 200 native vessel CTO lesion underwent PCI in Indonesian population. This predictive score was established from antegrade approach CTO-PCI in order to predict successful stent deployment. The score established as follows: Blunt stump (3 points), calcification (2 points), poor retrograde collateral filling (2 points), long lesion and bending had 1 point each. Lesion characteristics consistently proved as predictors of CTO-PCI success. In this study we analyzed all factors previously studied for CTO-PCI success. Morino *et al* introduced Japan-CTO (JCTO) score consist of calcification, bending, blunt stump, long lesion, and prior failed attempts as predictors of successful guide wire crossing within 30 minutes.[6] Our study found there were no difference of prior failed attempts in successfull and failed CTO-PCI as the J-CTO did. In respect to same Asian population, our study found different result from Busan CTO population where the age, gender, and target vessels were proved as predictor of CTO-PCI success.[14]

The presence of calcification led to difficulty to cross and dilate the CTO lesion and to deploy the stent.[15–18] Blunt stump morphology at proximal cap made difficulty to probe the occlusion with a wire.[19] In our study the blunt stump lesion also associated with more calcification and longer lession (p=0.011 and p=0.003), while long lesion associated with more extensive coronary disease and frequent intimal dissection.[20] Rentrop collaterals grade <2 reflect the poor distal vessel filling and made difficult for operator to visualize distal CTO lession in order to cross the lesion antegradely.[21] Poor retrograde collateral filling proved to be negative predictor of CTO-PCI success in our study (OR 44.31; p=0.001). Bending had p=0.076 and still stand with other significant variable in the last step of backward stepwise analysis as this variable may be had significant relation to CTO-PCI succes but had less significancy due to the sample size. Due to the consistent literature finding and this statistical reason we still put this variable a independent predictor.[6,22] Side branch in the entry point of CTO lession were not strong predictor while side

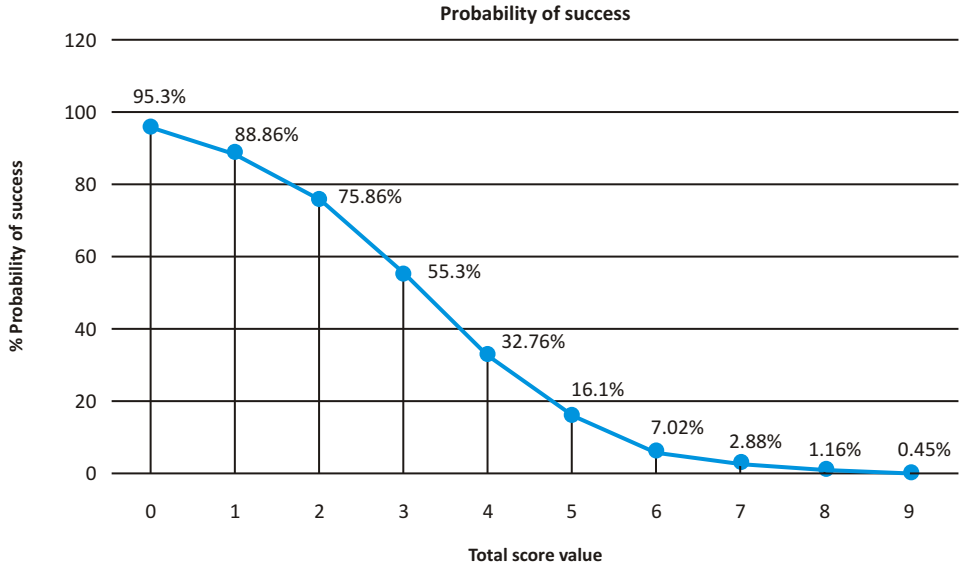

Figure 1. The probability of CTO-PCI success based on total score value

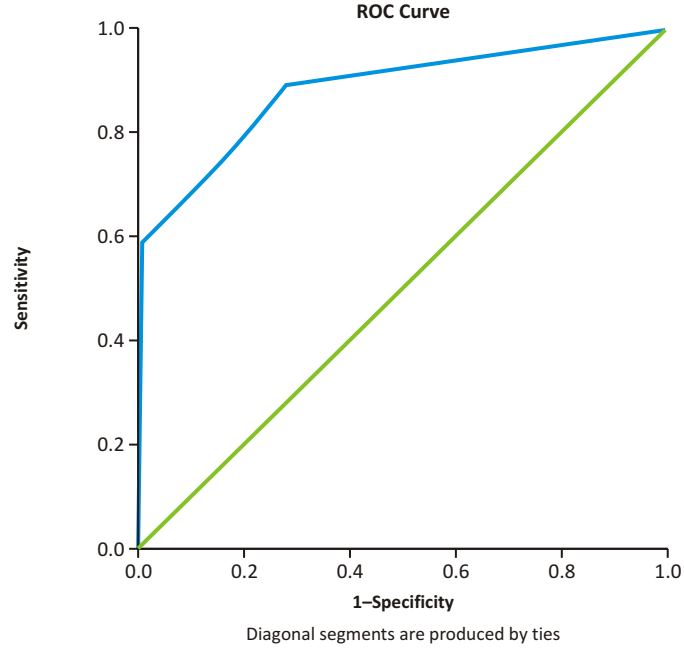

Figure 2. ROC AUC curve of the established prediction score

branch in the entry point with the presence of blunt stump found to be more significant independent predictor of CTO-PCI (OR 9.84; p<0.001). There was no significant difference in CTO-PCI success rate with respect to the artery involved. different from earlier studies that found non-LAD lesion had higher complexity ie longer lesion, more tortuous, more calcification, and poor retrograde collateral.[5,7,23] In our study these complex characteristics were not only identical in non-LAD vessel i.e non-LAD vessel had more bending lesion (p=0.022), LAD vessel had more calcification (p<0.001), and no difference of lesion length and collateral quality between the two group (p=0.071 and p=0.661).

In our study the success rate of CTO-PCI using antegrade approach was 75.5%. Jin *et al* found the primary success using antegrade CTO-PCI was 73.5% in Korean patients.[14] This result proved that antegrade CTO-PCI still had high procedural success. The hybrid CTO-PCI provided higher success rate but there has been infrequent adoption of the technique in developing

country due to the higher cost of the equipments needed.[9] Our score might be applicable in contemporary local settings of CTO-PCI, especially in other centers where the antegrade CTO-PCI approaches were still common. The established score could predict the lesion difficulty level and the probability of success in order to help the operators to plan the strategies of CTO-PCI or to refer the patient to the hybrid/retrograde CTO-PCI centers.

Study limitation

This score system was established from data collected in a single center performed CTO-PCI commonly use antegrade approach. The sample size of our study might be smaller than other study. The applicability of the score needs to be validated in other centers. Summation lesion characteristics, dedicated devices, and operator skills were associated with CTO-PCI success.[24] As the technique and CTO-specific devices are evolving, the score will require updating in the future.

CONCLUSION

The score established in our study were aim to predict successfull revascularization of CTO-PCI using antegrade approach in Indonesian population. The score model might be applicable in CTO-PCI centers where the retrograde or hybrid approach were rarely to use due to the higher costs of the later techniques. This model allows the identification of 2 subgroup score values corresponding to easy and difficult CTO lesion. The increasing score values correlate with lowerprobability of CTO-PCI success.

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