Outcomes after percutaneous coronary intervention and comparison among scoring systems in predicting procedural success in elderly patients (≥75 years) with chronic total occlusion

Ya-Min Su[a], Min Pan[b], Hai-Hua Geng[b], Rui Zhang[a], Yang-Yang Qu[a] and Gen-Shan Ma[a]

Background **Evidence-based data on percutaneous coronary intervention in elderly patients with chronic total occlusion (CTO) and comparison among different scoring systems have not been well established.**

Patients and methods **A total of 246 consecutive patients were stratified into two groups according to the age: elderly group (age≥75 years, *n*=68) and nonelderly group (age<75 years, *n*=178). Clinical and angiographic characteristics including the Synergy Between PCI With TAXUS and Cardiac Surgery score, in-hospital major adverse cardiac events, procedural success rates, and predictive capacity of four scoring systems [J-CTO, Prospective Global Registry for the Study of Chronic Total Occlusion Intervention (PROGRESS CTO), clinical and lesion-related (CL), and ostial location, Rentrop grade<2, age≥75 years (ORA) scores] were examined.**

Results **Triple-vessel disease and the Synergy Between PCI With TAXUS and Cardiac Surgery score in the elderly group were significantly higher than those in the nonelderly group (73.53 vs. 53.93%, *P*=0.005; 31.39±7.68 vs. 27.85±7.16, *P*=0.001, respectively). The in-hospital major adverse cardiac event rates, vascular access complication rates, and major bleeding rates were similar between the elderly and the nonelderly group (2.94 vs. 2.25%, *P*=0.669; 1.47 vs. 0.56%, *P*=0.477; 2.94 vs. 1.12%, *P*=0.306, respectively). By contrast, the procedural success rate was statistically lower in the elderly group than that in the nonelderly group (73.53 vs. 84.83%, *P*=0.040). All the four scoring systems showed a moderate predictive capacity [area under the curve (AUC) for J-CTO score: 0.806, *P*<0.0001; AUC for PROGRESS CTO score: 0.727, *P*<0.0001; AUC for CL score: 0.800, *P*<0.0001; AUC for ORA score: 0.672, *P*<0.0001, respectively]. Compared with the ORA score, the J-CTO score, and the CL score showed a significant advantage in predicting procedural success among overall patients (ΔAUC=0.134, *P*=0.0122; ΔAUC=0.128, *P*=0.0233, respectively).**

Conclusion **Despite the lower procedural success rate, percutaneous coronary intervention in elderly patients with CTO is feasible and safe. J-CTO, PROGRESS, ORA, and CL scoring systems have moderate discriminatory capacity.** *Coron Artery Dis* **30: 481–487 Copyright © 2019 The Author(s). Published by Wolters Kluwer Health, Inc.**

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Keywords: chronic total occlusion, elderly patient, outcomes, percutaneous coronary intervention, scoring systems

[a]Department of Cardiology, School of Medicine, Southeast University, Nanjing and [b]Department of Cardiology, Affiliated Hospital of Nantong University, Nantong, Jiangsu, People's Republic of China

Correspondence to Gen-Shan Ma, MD, PhD, Department of Cardiology, Zhongda Hospital, School of Medicine, Southeast University, No. 87 Dingjiaqiao, Nanjing 210009, Jiangsu, People's Republic of China
Tel: + 86 025 8326 2391; fax: + 86 025 8326 2395;
e-mail: magenshan@hotmail.com

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Introduction

Percutaneous coronary intervention (PCI) for chronic total occlusion (CTO) remains the most technically challenging procedure in the contemporary era. The availability of new sophisticated guidewires and other specialized technologies, especially the retrograde approach [1–3] and antegrade dissection and re-entry [4,5], have marked improved the interventional procedure success rate. As the population is progressively aging, the number of patients suffering from coronary artery diseases with CTO is expected to rise in the next decades. Elderly patients with CTO have a greater burden of concomitant diseases compared with young patients [6]. The complexity of the clinical conditions and the increased risk associated with a specific treatment often affect doctors' decision, making patients' families more inclined to choose a conservative drug treatment or PCI, instead of coronary artery bypass graft. However, scarce evidence-based data are available on the safety and efficacy of PCI in the elderly CTO patients because of their exclusion and under-representation in clinical trials. Therefore, it is of great clinical and social significance to study the interventional treatments

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associated with CTO disease in elderly patients, including success rate, safety, and effectiveness.

Emerging studies showed that a successful PCI procedure for CTO is associated with better clinical outcomes in terms of reduced mortality and major adverse cardiac events [7–11]. To enhance the procedural success and risk–benefit ratio of CTO PCI, the pre-procedural accurate evaluation is particularly significant because it would help the procedural planning and/or the need to transfer patients to another experienced center. Because of the above purpose, various scoring systems have been developed to predict CTO PCI procedural success, including the J-CTO (Multicenter CTO Registry in Japan) score [12], the Prospective Global Registry for the Study of Chronic Total Occlusion Intervention (PROGRESS CTO) Score [13], the clinical and lesion-related (CL) score [14], and the ostial location, Rentrop grade < 2, age ≥ 75 years (ORA) score [15]. However, the clinical data on the one that is more suitable for CTO patients have not been well established.

Therefore, this study is a retrospective cohort report from a Chinese single center, presenting the clinical characteristics of elderly patients (≥ 75 years) with CTO diseases and in-hospital outcomes after PCI in the contemporary era. Another aim of this study is to assess different scoring systems in predicting the procedural success in the real world to enhance PCI clinical safety and efficacy.

Patients and methods

Enrolled patients and parameters

A total of 246 consecutive patients who underwent elective CTO PCI in Zhongda hospital from January 2017 to March 2018 were enrolled in this study. These patients were stratified into two groups according to age: the elderly group (age ≥ 75 years, $n = 68$) and the nonelderly group (age < 75 years, $n = 178$). All patients' symptoms and medical history were collected by clinicians. Measurements of leukocytes, erythrocytes, hemoglobin, platelets, random glucose, creatinine, total cholesterol, high density lipoprotein-cholesterol, low density lipoprotein-cholesterol, triglycerides and ultrasonic cardiogram were performed before the PCI procedure. Myocardial injury biomarkers [creatine kinase-MB (CK-MB) and/or troponin] were measured routinely before and after the PCI procedure. All patients signed the informed consent on the interventional operation, which was approved by the hospital ethics committee.

Interventional procedure

Aspirin and a P2Y12 receptor inhibitor (clopidogrel or ticagrelor) were administered orally before PCI. In addition, a bolus of unfractionated heparin (70–100 IU/kg) was administered after the sheath was placed into the radial and/or the femoral artery access. The Synergy Between PCI With TAXUS and Cardiac Surgery (SYNTAX) score, the J-CTO score, the PROGRESS CTO score, the CL score, and the ORA score were calculated by two independent experienced CTO experts on the basis of the coronary angiography. Contemporary techniques and devices, such as bilateral coronary angiography, dedicated wires, microcatheters, retrograde approaches, and antegrade dissection, and re-entry were performed when and if needed during the recanalization of CTO lesions. Following elective stenting, an antiplatelet therapy consisting of clopidogrel or ticagrelor in addition to aspirin was recommended according to the guidelines on myocardial revascularization [16–18].

Study endpoints and definitions

The primary endpoints were in-hospital major adverse cardiac events (MACEs). The secondary endpoint was the procedural success rate. In addition, the effectiveness of the different scoring systems in predicting CTO procedural success was assessed.

CTO was defined as coronary complete occlusion [thrombolysis in myocardial infarction (MI) flow grade 0] with a duration of at least 3 months. The occlusion duration was estimated according to a previous history of myocardial infarction, first onset of angina symptoms, or comparison with a previous angiogram. In-hospital MACEs included the following adverse events before hospital discharge: death, peri-procedural MI, Q-wave MI, recurrent symptoms requiring the urgent repetition of the PCI in the target vessel or coronary artery bypass graft surgery, tamponade requiring either pericardiocentesis or surgical intervention, and stroke [19]. Procedural success was defined as the complete restoration of the antegrade blood flow (thrombolysis in MI flow grade 3) with an arterial lumen diameter reduction to less than 30% in the culprit CTO vessel [20]. Peri-procedural MI was diagnosed on the basis of the expert consensus document from the Society for Cardiovascular Angiography and Interventions [21]. Briefly, peri-procedural MI was diagnosed when the CK-MB peak, measured within 48 h of the procedure, increased to at least 10 times the upper limit of normal (ULN), or increased to at least 5× ULN with new pathologic Q-waves in at least two contiguous leads or with new persistent left bundle branch block. In the absence of CK-MB measurement, peri-procedural MI was diagnosed when a troponin level, measured within 48 h of the PCI, increased to at least 70× ULN, or at least 35× ULN with new pathologic Q-waves in at least two contiguous leads or with new persistent left bundle branch block [21]. Major bleeding was defined as bleeding causing a hemoglobin drop of at least 3 g/dl or bleeding requiring transfusion or surgical intervention. Vascular access complications were defined as major bleeding from the access site or other complications requiring surgical intervention.

Statistical analysis

Statistical analysis was carried out using SPSS, version 21.0 (IBM Corporation, Armonk, New York, USA)

and MedCalc, version 18.2.1 (MedCalc Software bvba, Ostend, Belgium). Continuous variables were expressed as mean ± SD, whereas categorical data were expressed as numbers obtained by direct count. χ^2-Test was applied to evaluate trends and differences among categorical data, while Student's *t*-test was used to evaluate the difference between two continuous variables, as appropriate. When more than 25% of the values showed an expected cell frequency less than 5, the Fisher exact test was preferred. Receiver operating characteristic curve and area under the curve (AUC) were used to evaluate the effectiveness of different CTO scoring systems. All tests were two-tailed, and differences were considered statistically significant at *P* value less than 0.05.

Results

Baseline characteristics

Among the 246 patients enrolled, 68 were older than 75 years, accounting for 27.64%, representing a significant proportion who underwent recanalization for CTOs. Elderly patients with CTO had a greater burden of concomitant diseases compared with the nonelderly, manifesting higher rates of renal dysfunction, chronic lung disease, and also a previous cerebral stroke. However, the elderly patients had a significantly lower smoking status, hyperlipidemia history, erythrocyte count, hemoglobin and triglyceride levels. Besides, the percentage of men was higher in the nonelderly group, suggesting the cardioprotective effect of estrogen, which was consistent with previous reports [22,23]. The baseline characteristics are shown in Table 1.

Table 1 Baseline characteristics stratified according to age

Variables	Elderly (*n*=68)	Nonelderly (*n*=178)	*P* value
Age (years)	79.43±3.289	62.78±8.478	0.000
Male [*n* (%)]	38 (55.88)	136 (76.40)	0.002
Hypertension [*n* (%)]	58 (85.29)	132 (74.16)	0.062
Diabetes mellitus [*n* (%)]	23 (33.82)	67 (37.64)	0.578
Renal dysfunction [*n* (%)]	8 (11.76)	7 (3.93)	0.046
Chronic lung disease [*n* (%)]	10 (14.71)	12 (6.74)	0.050
Hyperlipidemia [*n* (%)]	4 (5.88)	30 (16.85)	0.026
Smoking [*n* (%)]	12 (17.65)	56 (31.46)	0.030
NYHA class≥3 [*n* (%)]	16 (23.53)	41 (23.03)	0.934
Previous PCI [*n* (%)]	29 (42.65)	71 (39.89)	0.694
Previous MI [*n* (%)]	11 (16.18)	42 (23.60)	0.206
Previous stroke [*n* (%)]	30 (44.1)	36 (20.22)	0.000
Leukocyte count (10^9/l)	7.22±2.46	7.15±2.22	0.826
Erythrocyte count (10^{12}/l)	4.09±0.59	4.41±0.62	0.000
Hemoglobin (g/l)	123.16±19.00	134.98±19.03	0.000
Platelet count (10^9/l)	203.56±72.50	203.99±69.11	0.966
Random glucose (mmol/l)	6.92±3.31	6.81±2.46	0.796
TG (mmol/l)	1.43±0.58	1.78±0.93	0.001
TC (mmol/l)	3.88±0.95	4.04±1.11	0.293
LDL-C (mmol/l)	2.27±0.79	2.40±0.90	0.299
HDL-C (mmol/l)	1.05±0.21	1.03±0.25	0.601
Creatinine (μmol/l)	110.09±87.78	98.48±89.59	0.362
LVEF	0.57±0.13	0.58±0.12	0.774

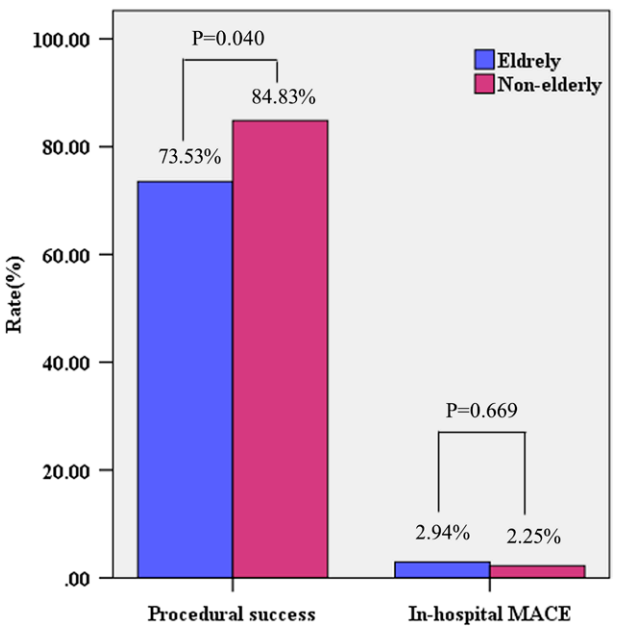
HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein-cholesterol; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NYHA, New York Heart Association; PCI, percutaneous coronary intervention; TC, total cholesterol; TG, triglyceride.

Table 2 Angiographic and procedural characteristics between elderly and nonelderly groups

Variables	Elderly (*n*=68)	Nonelderly (*n*=178)	*P* value
CTO location [*n* (%)]			0.110
LAD	36 (52.94)	80 (44.94)	0.261
LCX	7 (10.29)	39 (21.91)	0.037
RCA	25 (36.76)	59 (33.15)	0.592
Number of narrowed vessel [*n* (%)]			0.013
1	3 (4.41)	24 (13.48)	0.042
2	15 (22.06)	58 (32.58)	0.106
3	50 (73.53)	96 (53.93)	0.005
Rentrop grade≥2 [*n* (%)]	41 (60.29)	98 (55.06)	0.459
SYNTAX score	31.39±7.68	27.85±7.16	0.001
Prediction scores			
J-CTO score	1.72±0.93	1.62±0.81	0.394
PROGRESS CTO score	1.22±0.88	1.43±0.77	0.071
CL score	2.82±1.34	2.76±1.22	0.735
ORA score	2.09±1.06	0.96±0.99	0.000
Average stent diameter (mm)	2.77±0.38	2.76±0.34	0.707
Average stent length (mm)	27.15±6.87	28.37±6.82	0.169
Retrograde approach [*n* (%)]	15 (22.06)	43 (24.16)	0.729
Contrast volume (ml)	182.81±68.07	242.09±62.95	0.000
Procedure time (min)	112.13±44.85	130.42±46.36	0.006
Vascular access complication [*n* (%)]	1 (1.47)	1 (0.56)	0.477
Major bleeding [*n* (%)]	2 (2.94)	2 (1.12)	0.306
In-hospital MACE [*n* (%)]	2 (2.94)	4 (2.25)	0.669
Procedural success [*n* (%)]	50 (73.53)	151 (84.83)	0.040

CL, clinical and lesion-related; CTO, chronic total occlusion; J-CTO, Multicenter CTO Registry in Japan; LAD, left anterior descending artery; LCX, left circumflex coronary artery; MACE, major adverse cardiac event; ORA, ostial location, Rentrop grade<2, age≥75 years; PROGRESS CTO, Prospective Global Registry for the Study of Chronic Total Occlusion Intervention; RCA, right coronary artery; SYNTAX, Synergy Between PCI With TAXUS and Cardiac Surgery.

Fig. 1



Procedural success and in-hospital MACE rates between the elderly and the nonelderly group. MACE, major adverse cardiac event.

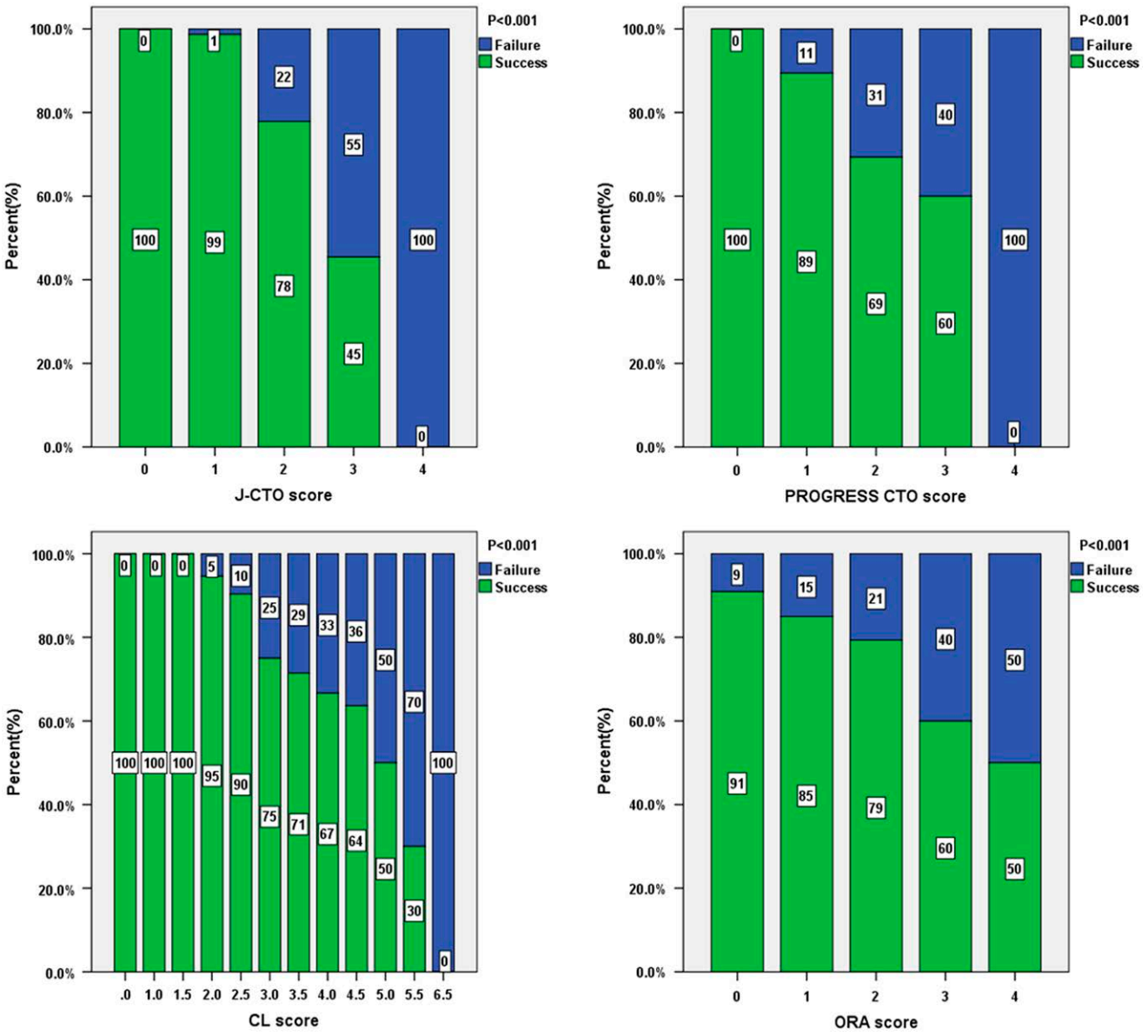
Angiographic characteristics

The angiographic characteristics of the two groups are shown in Table 2. The targeted CTO lesions were most frequently located at the left anterior descending artery in both the elderly group (52.94%) and the nonelderly group (44.94%). No statistically significant difference was observed in the level of coronary arterial collateral circulation (Rentrop grade ≥ 2 class) between the two groups. However, the percentages of patients with triple-vessel disease and SYNTAX score in the elderly group were significantly higher than those in the nonelderly group (73.53 vs. 53.93%, $P = 0.005$; 31.39 ± 7.68 vs. 27.85 ± 7.16, $P = 0.001$, respectively), indicating that the elderly CTO patients had more severe coronary arterial lesions.

In-hospital major adverse cardiac events and procedural success rate

As shown in Table 2, procedure time and contrast volume in the elderly group were lower than that in the nonelderly group. However, the difference was not significant in the average stent diameter, the average stent length and retrograde approach utilization.

Fig. 2



Procedural success rates for different strata of various scoring systems (*P* values for trend). CL, clinical and lesion-related; J-CTO, Multicenter CTO Registry in Japan; ORA, ostial location, Rentrop grade less than 2, age at least 75 years; PROGRESS CTO, Prospective Global Registry for the Study of Chronic Total Occlusion Intervention.

Two in-hospital MACEs occurred in the elderly group (peri-procedural MI and pericardial tamponade caused by coronary perforation in one patient, peri-procedural MI in one patient), whereas they occurred in four patients in the nonelderly group (death of one patient, peri-procedural MI and pericardial tamponade caused by coronary perforation in one patient, peri-procedural MI requiring urgent PCI in one patient, peri-procedural MI in one patient). The in-hospital MACE rates, vascular access complication rates and major bleeding rates were similar between the elderly and the nonelderly group (2.94 vs. 2.25%, $P=0.669$; 1.47 vs. 0.56%, $P=0.477$; 2.94 vs. 1.12%, $P=0.306$, respectively). Details are shown in Table 2.

The total procedural success rate was 81.71% in 246 CTO patients, which was statistically lower in the elderly group than that in the nonelderly group (73.53 vs. 84.83%, $P=0.040$) (Fig. 1).

Table 3 Comparison of scoring systems in predicting procedural success

	Elderly		Entirety	
Variables	AUC	95% CI	AUC	95% CI
J-CTO	0.791	0.688–0.894	0.806	0.753–0.859
PROGRESS	0.788	0.684–0.893	0.727	0.656–0.799
CL	0.711	0.576–0.845	0.800	0.737–0.863
ORA	0.703	0.573–0.834	0.672	0.587–0.757
Variables	ΔAUC	*P* value	ΔAUC	*P* value
J-CTO vs. PROGRESS	0.00278	0.9715	0.0794	0.0934
J-CTO vs. CL	0.0806	0.3385	0.00674	0.8539
J-CTO vs. ORA	0.0878	0.3498	0.134	0.0122
PROGRESS vs. CL	0.0778	0.3396	0.0727	0.1156
PROGRESS vs. ORA	0.0850	0.1184	0.0550	0.1531
CL vs. ORA	0.00722	0.9420	0.128	0.0233

AUC, area under curve; CI, confidence interval; CL, clinical and lesion-related; J-CTO, Multicenter CTO Registry in Japan; ORA, ostial location, Rentrop grade<2, age≥75 years; PROGRESS, Prospective Global Registry for the Study of Chronic Total Occlusion Intervention.

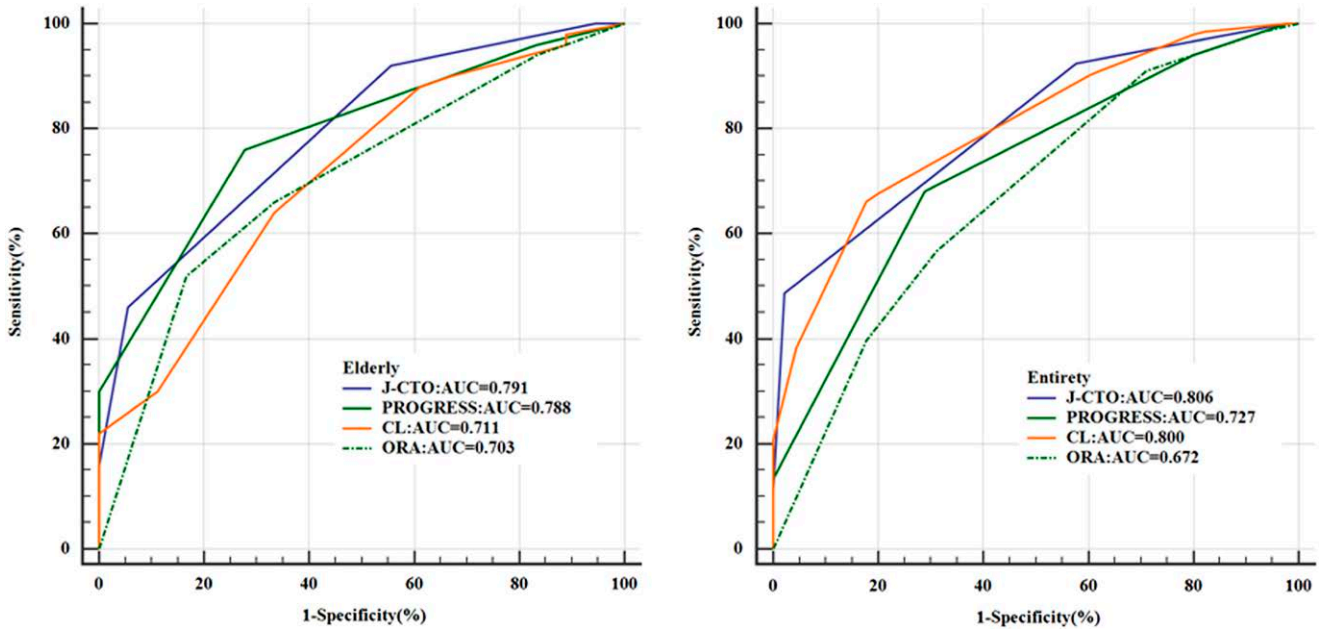
Discriminatory performance of the scoring systems in predicting the procedure success

With increasing strata, the procedural success rate was significantly reduced in all scoring systems (P for trend<0.001, Fig. 2). All the four score systems showed a moderate predictive capacity (AUC for J-CTO score: 0.806, $P<0.0001$; AUC for PROGRESS CTO score: 0.727, $P<0.0001$; AUC for CL score: 0.800, $P<0.0001$; AUC for ORA score: 0.672, $P<0.0001$, respectively). The J-CTO score and the CL score showed a significant advantage than the ORA score in overall patients (ΔAUC=0.134, $P=0.0122$; ΔAUC=0.128, $P=0.0233$, respectively). By contrast, in the elderly group, no significant difference was observed among the four scoring systems. Details are shown in Table 3 and Fig. 3.

Discussion

The present retrospective study was carried out in a cohort of 246 consecutive patients who underwent the CTO-PCI procedure, in which 68 were older than 75 years, accounting for 28% of the total. Our single-center

Fig. 3



Receiver operating characteristic (ROC) curves in predicting procedural success. AUC, area under curve; CL, clinical and lesion-related; CTO, chronic total occlusion; J-CTO, Multicenter CTO Registry in Japan; ORA, ostial location, Rentrop grade less than 2, age at least 75 years; PROGRESS, Prospective Global Registry for the Study of Chronic Total Occlusion Intervention.

real-world study confirmed that the elderly group accounted for a significant proportion of patients with CTO.

Aging is an independent predictor of adverse cardiovascular events [24], and the aging population in China is gradually increasing [25]. Our study indicated that elderly patients with CTO had more complications and more severe coronary lesions, manifesting more pronounced renal dysfunctions, chronic lung diseases, previous cerebral strokes, triple-vessel diseases, and high SYNTAX scores, which were consistent with previous reports [6,26].

The data from our center showed no significant difference in vascular access complications, major bleeding, and in-hospital MACE rates between elderly and nonelderly groups, suggesting that PCI therapy for the elderly CTO patients was safe and feasible. However, the procedural success rate in the elderly population was statistically lower than that in the nonelderly group (73.53 vs. 84.83%, $P=0.040$), which was consistent with previous studies in elderly patients [6]. The lower procedural success rate in the elderly might be partially attributed to less procedure time (112.13 ± 44.85 vs. 130.42 ± 46.36, $P=0.006$).

To enhance the procedural success rate and avoid potential risks, various scoring systems have been developed. The J-CTO score [12], the first and most widely used CTO prediction system, was originally created to predict the possibility of successful guidewire crossing within 30 min. The PROGRESS CTO score [13], based on four angiographic variables, can estimate CTO technical success in the contemporary hybrid era. The CL score [14], which includes both clinical and angiographic variables, is more suitable for the evaluation of the first-attempt CTO-PCI procedure by the antegrade approach. The ORA score [15], derived from the procedure performed by a single CTO-dedicated operator, may be not applicable to the overall CTO operators. The data from our center showed that the J-CTO score and the CL score had a statistical advantage in overall CTO patients over the ORA score. However, all four scoring systems showed intermediate discriminatory performance in predicting CTO procedural success.

Our study has some limitations. First, a retrospective cohort study has its inherent limitation, with an inevitable case selection bias. Second, the number of patients enrolled from a single center is relatively small. Our results might not be representative for other centers. Third, our study does not evaluate data on the long-term effect of CTO-PCI in senile patients, which is another meaningful issue of relevance for clinicians.

Conclusion

Elderly patients with CTO tend to have more severe complex lesions and a greater burden of concomitant diseases. Despite the lower procedural success rate in the elderly group, PCI for the elderly CTO population is feasible and safe, as this population has a high probability of vascular access complication rate, major bleeding rate, and in-hospital MACE rate. All J-CTO, PROGRESS, ORA and CL scoring systems have moderate discriminatory capacity in predicting the procedure success. Integration of multiple scoring systems would be useful to evaluate the procedural risk–benefit ratio more accurately.

Acknowledgements

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Conflicts of interest

There are no conflicts of interest.

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