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Impact of complete revascularization with percutaneous coronary intervention on survival in patients with at least one chronic total occlusion

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Aims This study sought to determine the impact on survival of successful drug-eluting stent-supported percutaneous coronary intervention (PCI) for chronic total occlusion (CTO).

Methods and results Comparison of long-term cardiac survival of consecutive patients who underwent PCI for at least one CTO and who were stratified into successful and failure procedures. From 2003 to 2006, 486 patients underwent PCI for 527 CTO. CTO–PCI was successful in 344 patients (71%) and 361 lesions (68%). Multivessel PCI was performed in 62% in the CTO–PCI failure group and in 71% in the CTO–PCI success group ($P = 0.062$). Cardiac survival rate was higher in the CTO–PCI success group compared with CTO–PCI failure group (91.6 ± 2.0 vs. $87.4 \pm 2.9\%$; $P = 0.025$), in patients with multivessel disease and CTO–PCI success compared with CTO–PCI failure (91.4 ± 2.2 vs. $86.6 \pm 3.1\%$; $P = 0.021$), and in patients with complete revascularization when compared to patients with incomplete revascularization (94.0 ± 1.7 vs. $83.8 \pm 3.6\%$; $P < 0.001$).

Conclusion Successful CTO–PCI confers a long-term survival benefit. Improvement in survival is driven by the differences in the outcome of patients with multivessel disease and who were completely revascularized.

Keywords Percutaneous coronary intervention • Chronic total occlusion • Drug-eluting stent

Introduction

Chronic coronary total occlusion (CTO) is frequent and registry studies report an incidence from 30% to 50% in patients with significant coronary artery disease undergoing coronary angiography.[1,2] The rationale for percutaneous CTO revascularization is improvement in survival and quality of life as showed by some retrospective studies.[3–5] Despite this strong rationale, there is no evidence based on randomized trials that successful CTO revascularization increases survival while large registry studies have produced conflicting results. Again, the robustness of the results of previous retrospective non-randomized studies is hampered by the relatively low percutaneous coronary intervention (PCI) success rate despite the selection of CTO with favourable characteristics for PCI, the very high rate of restenosis or reocclusion after successful balloon angioplasty or bare metal stent implantation, the lack of routine angiographic follow-up assessing the maintained patency of the treated vessel, the inclusion of patients with occlusion standing less than 3 months.[3,4] Development of novel technologies and techniques, including the use of drug-eluting stents (DES), implies high procedural success rate with high long-term vessel patency[6–12] and simultaneously allows the assessment of the true impact on survival of successful PCI for CTO.

This study sought to determine the efficacy of DES-supported PCI and the impact of completeness of revascularization on survival in a series of 486 consecutive patients with at least one CTO.

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Methods

Patients

From January 2003 to December 2006 patients who underwent PCI for at least one CTO were included in the study. CTO was defined as a coronary obstruction with TIMI flow grade 0 with an estimated duration of >3 months. The duration of the occlusion was determined by the interval from the last episode of acute coronary syndrome (ACS), or in patients without a history of ACS, from the first episode of effort angina consistent with the location of the occlusion, or by a previous coronary angiography. In patients without a history of angina and who were admitted for an ACS or ST-segment elevation acute myocardial infarction (AMI) with a definite identification of the culprit vessel, associated total occlusion of a non-culprit vessel was considered as a chronic occlusion if there was angiographic evidence of filling the vessel through collaterals. The indication for the percutaneous treatment of CTO was the demonstration of viable myocardium in the territory of the occluded vessel by echographic or scintigraphic provocative tests, while no CTO angiographic characteristic was considered as an absolute contraindication to PCI attempt. Thus, patients with long occlusions, or extensive calcification, or bridging collaterals, or a non-tapered stump, or a side branch at the occlusion site, or CTO of a venous graft were included.

Treatment

All occlusions were attempted using the anterograde approach and dedicated coronary wires (hydrophilic and non-hydrophilic) and devices. Coronary wire types included: Whisper, Pilot 150 and 200 (Abbott Vascular, Santa Clara, CA, USA), Miracle 6, Confianza and Confianza PRO (Asahi, Abbott Laboratories, Redwood City, CA, USA). Either sirolimus-eluting stent (Cypher, Cordis Corp., Miami Lakes, FL, USA) or paclitaxel-eluting stent (Taxus, Boston Scientific Corp., Natick, MA, USA) were routinely used for CTO successfully crossed with a coronary wire and predilated with a restoration of a Thrombolysis In Myocardial Infarction (TIMI) flow grade 2 or 3. The type of the stent used was at discretion of the operator. Standard stent implantation techniques, including routine post-dilation using final high balloon pressure (≥16 atm) were used. In patients with long occlusions, or occlusion in a diffusely diseased vessel, a policy of complete coverage of the disease was adopted using long stents or multiple stents. Provisional rotational atherectomy was performed if no angioplasty balloon could cross the lesion, or the balloon could not dilate the target lesion.

Standard techniques were used for non-CTO lesions in patients with multivessel disease. Bare metal stents were used in patients admitted for ST-segment elevation AMI, while DES were used in all the remaining cases. Multivessel disease was defined as a stenosis ≥70% of one or two major coronary arteries on visual assessment of baseline angiography besides the CTO vessel. Patients with a multistaged procedure were included if the second procedure was performed within 2 months from the first intervention.

All patients were pre-treated with aspirin (300 mg/day) and clopidogrel (loading dose 600 mg). Glycoprotein IIb/IIIa inhibitors were used only after successful CTO wiring and predilation without angiographic evidence of perforation and a suboptimal result after stenting. Aspirin (300 mg/day) was continued indefinitely, while clopidogrel (75 mg/day) for at least 6 months.

Procedural success was defined as a final diameter stenosis <30% with a TIMI grade flow 3 of all the treated vessels without death, non-Q-wave or Q-wave myocardial infarction (MI), or emergency coronary surgery. Non-Q-wave MI was defined as an increase in creatine kinase-MB fraction of three times the upper limit of normal, or for patients with elevated values on admission as a re-elevation of creatine kinase-MB values. Creatine kinase-MB fraction was routinely assessed 12 h after PCI in all patients or at least three times every 6 h in patients with recurrent chest pain. A Q-wave MI was defined as new Q-wave in two or more contiguous leads in addition to creatine kinase-MB elevation.

Complete revascularization was defined as a restoration of TIMI grade 3 flow with residual stenosis <30% on visual assessment in the three coronary arteries and their major branches (branch diameter ≥2 mm).

Quantitative coronary angiography

Quantitative coronary angiography of the CTO procedure included the measurement of reference vessel diameter, and the minimum lumen diameter before the procedure, immediately after the procedure, and during follow-up. Lesion length was assessed from the beginning of the occlusion to distal antegrade or retrograde vessel filling from bridge collaterals or collaterals provided by a coronary artery other than the CTO vessel, and using if necessary simultaneous contrast medium injection in both right and left coronary arteries. These quantitative angiographic parameters were assessed using a semi-automated edge-contour-detection computer analysis system (ANCOR II, Siemens, Solna, Sweden). Angiographic in-segment restenosis was defined as >50% luminal narrowing at the segment site including the stent and 5 mm proximal and distal to the stent edges of the target vessel on the follow-up angiography.

Follow-up

All patients had scheduled clinical and electrocardiographic examinations at 6 months, and at 1 and 2 years. All other possible informations derived from hospital re-admission or by the referring physician, relatives, or municipality live registries were entered into a prospective database. All the eligible patients with successful CTO–PCI success were scheduled for angiographic follow-up at 6–9 months. Unscheduled angiography was allowed on the basis of clinical indication.

Endpoint

The primary endpoint is cardiac survival. All deaths were considered cardiac unless otherwise documented.

Statistical analysis

Discrete data are summarized as frequencies, while continuous as mean ± SD or median and inter-quartile range (IQR). χ^2 test or Fisher exact test analysis were used for comparison of categorical variables. A Student's *t*-test or the Mann–Whitney *U* test when appropriate were used to test differences among continuous variables. A paired *t*-test was used to test the difference between paired data. Cumulative survival analyses were performed using the Kaplan–Meier method, and the difference between curves was assessed by log-rank test. Univariable and multivariable Cox proportional hazards model were performed to evaluate the independent contribution of clinical, angiographic, and procedural variables to cardiac mortality. Variables with a *P*-value <0.10 were entered into the multivariable model. The following variables were tested: age, gender, hypertension, hypercholesterolaemia (>200 mg/dL), current smoker, diabetes mellitus, previous MI, left ventricular ejection fraction (LVEF), previous PCI, previous coronary surgery revascularization, ACS on admission, three-vessel disease, CTO vessel, CTO-PCI success, completeness of revascularization. The proportional hazard assumption was assessed and satisfied graphically by plotting log (−log) survival curves against log survival time for

each predictor category in the final model and verifying whether curves were parallel, and in addition using time-dependent covariates. Linearity was checked graphically using the smoothed martingale residuals from the null model plotted against the covariate variables. Hazards ratio (HR) and their 95% confidence intervals (CI) were calculated. All the tests were two-tailed. A *P*-value <0.05 was considered significant. Analyses were performed using the software packages SPSS 11.5 (SPSS Inc., Chicago, IL, USA) and NCSS 2007 (NCSS, Kaysville, UT, USA).

Results

From January 2003 to December 2006, 486 patients underwent PCI for at least one CTO. Out of 100 patients with more than one CTO, 41 had attempted PCI of two CTO resulting in a total of 527 CTO treated. Patients with revascularization attempt of two CTO and a successful procedure of only one of the two lesions were categorized as PCI success and incomplete revascularization. During the same period, 28 patients with CTO and viable myocardium did not undergo PCI attempt because of renal insufficiency (21 patients), or patient or referring physician willingness for coronary surgery or medical therapy (seven patients).

Table 1 summarizes the baseline clinical and angiographic characteristics with respect to success or failure of the CTO procedure. Patients with unsuccessful PCI were older (69.8 ± 10.9 vs. 67.4 ± 11.1 years; $P = 0.036$), and had a higher incidence of previous coronary surgery (18 vs. 8%; $P = 0.002$) when compared to patients with successful CTO revascularization. A history of previous MI was present in nearly half of the patients in both groups. Most patients in both groups had multivessel disease and more than half had three-vessel disease. Only 11% of patients were admitted for ST-segment elevation AMI, and in all cases the CTO revascularization attempt was staged 3–6 weeks after primary PCI of the acute infarct-related artery. Thirty-seven percent of patients were admitted for ACS. CTO location was in most patients in the main branch of one of the three coronary arteries, while in 12% of the cases it was in side branches supplying large amount of myocardium (>10% of LV) or venous grafts.

CTO–PCI was successful in 344 patients (71%) and 361 lesions (68%). *Table 2* summarizes the procedural characteristics and outcome. Out of 41 patients with recanalization attempt of two CTO, PCI was successful in both CTO in 17 patients, in only one in

Table 1 Baseline clinical and angiographic characteristics

	CTO–PCI failure ($n = 142$)	CTO–PCI success ($n = 344$)	*P*-value
Age (years)	69.8 ± 10.9	67.4 ± 11.1	0.036
>75 years, *n* (%)	51 (36)	87 (25)	0.018
Male, *n* (%)	118 (83)	277 (81)	0.508
Hypertension, *n* (%)	81 (57)	196 (57)	0.989
Hypercholesterolaemia, *n* (%)	72 (51)	173 (50)	0.933
Current smokers, *n* (%)	31 (22)	68 (20)	0.607
Diabetes mellitus, *n* (%)	30 (21)	83 (24)	0.476
Previous myocardial infarction, *n* (%)	76 (54)	153 (45)	0.069
Previous PCI	42 (30)	85 (25)	0.267
Previous coronary surgery, *n* (%)	25 (18)	28 (8)	0.002
Stable angina, *n* (%)	80 (56)	173 (50)	0.225
ACS, *n* (%)	46 (32)	135 (39)	0.155
AMI (non-CTO vessel)	16 (11)	36 (10)	0.795
LVEF (%)	41 ± 14	42 ± 13	0.343
LVEF<40%, *n* (%)	54 (38)	113 (33)	0.333
Double CTO, *n* (%)	27 (19)	73 (21)	0.584
Multivessel disease, *n* (%)	124 (87)	292 (85)	0.485
Three-vessel disease, *n* (%)	76 (54)	180 (52)	0.810
Left main disease, *n* (%)	14 (10)	26 (8)	0.401
Unprotected, *n*	7	19	
CTO vessel, *n* (%)	($n = 166$)	($n = 361$)	0.155
LAD	54 (33)	97 (27)	
LCx	29 (17)	63 (18)	
RCA	60 (36)	160 (44)	
Venous graft	5 (3)	3 (1)	
Others	18 (11)	38 (10)	

ACS, acute coronary syndrome (includes unstable angina and non-ST-segment elevation myocardial infarction); AMI, acute ST-segment elevation myocardial infarction; CTO, chronic total occlusion; LAD, left anterior descending artery; LCx, left circumflex; LVEF, left ventricular ejection fraction; PCI, percutaneous coronary intervention; RCA, right coronary artery.

Table 2 Procedural characteristics

Lesions	CTO–PCI failure ($n = 166$)	CTO–PCI success ($n = 361$)	*P*-value
Occlusion length (mm); median (IQR)	25 (15–52.5)	28 (21–47.5)	0.134
Length>20 mm, *n* (%)	111 (67)	254 (70)	0.420
Reference CTO diameter (mm)	2.61 ± 0.54	2.66 ± 0.51	0.305
Diameter<2.5 mm, *n* (%)	45 (27)	103 (29)	0.736
CTO stent implanted, *n*	–	646	
Paclitaxel (%)		58	
Sirolimus (%)		42	
CTO stent length (mm); median (IQR)		40 (25–66)	
Post-PCI minimum lesion diameter (mm)		2.69 ± 0.50	
	($n = 142$)	($n = 344$)	
Multivessel PCI, *n* (%)	96 (62)	268 (71)	0.062
Two-vessel	60 (42)	141 (41)	0.797
Three-vessel	28 (20)	102 (30)	0.024
Left main	8 (6)	25 (7)	0.515
Non-CTO lesions, *n*	148	480	
Fluoroscopic time (min); median (IQR)	24 (16–30)	20 (12–30)	0.010
Contrast use (ml); median (IQR)	300 (200–400)	300 (200–400)	0.719
Completeness of revascularization, *n* (%)[a]	13 (9)	288 (84)	<0.001

CTO, chronic total occlusion; IQR, inter-quartile range; PCI, percutaneous coronary intervention.
[a]Includes 13 patients of the CTO–PCI failure group and seven patients of the CTO–PCI success group who underwent coronary bypass surgery after PCI.

20 patients, and unsuccessful in both occlusions in four. The median stent length for successfully treated CTO was 40 mm (25–66).

The majority of patients in successful and failed CTO revascularization groups, had intervention in vessels other than the CTO vessel. Two-vessel intervention was performed in 42% in the CTO–PCI failure group and in 41% in the CTO–PCI success group, while three-vessel intervention was performed in 20 and 30%, respectively. Patients with three-vessel intervention include 33 patients with left main intervention (unprotected left main 22 patients, protected left main 11 patients). Including CTO lesions, in the failed CTO–PCI group and in the successful CTO–PCI group, the mean number of lesions treated per patient was 2.2 and 2.5, and the mean number of stents per patient was 1.8 and 4.1, respectively.

There were no procedural deaths or Q-wave MIs. The incidence of non-Q-wave MI was 4%. Other major non-fatal complications include cardiac tamponade (two patients), transitory appearance or worsening of previous renal insufficiency (18 patients), major bleeding according to the TIMI criteria (18 patients).

Complete revascularization could be achieved by PCI in 84% of CTO–PCI success group. Among patients with incomplete revascularization, 9% of the CTO–PCI failure group and 2% of the CTO–PCI success group underwent elective coronary artery bypass surgery, and these patients were categorized as having complete revascularization.

Table 3 summarizes the clinical outcome. The median length of the survival follow-up was 2.0 years (IQR 1.1–2.8 years), and the follow-up rate was 100%.

Cardiac survival rate was 91.6 ± 2.0% in the CTO–PCI success group and 87.4 ± 2.9% in the CTO–PCI failure group ($P = 0.025$). *Figure 1* shows the cumulative cardiac survival curves with respect to CTO–PCI success or failure.

There were no differences in cardiac mortality between CTO–PCI success and CTO–PCI failure in patients with single vessel disease, while patients with multivessel disease and CTO–PCI success exhibited a higher cardiac survival when compared with CTO–PCI failure (91.4 ± 2.2 and 86.6 ± 3.1%, respectively; $P = 0.021$). Cardiac survival was higher in patients with complete revascularization when compared to patients with incomplete revascularization (94.0 ± 1.7 vs. 83.8 ± 3.6%; $P < 0.001$) (*Figure 2*).

Table 4 summarizes the results of univariable and multivariable analysis. Variables associated with cardiac mortality with a *P*-value <0.10 at the univariate analysis, were age, previous MI, LVEF, CTO vessel, CTO–PCI success, and completeness of revascularization. Since successful CTO–PCI (HR 0.49; $P = 0.029$) was a prerequisite of complete revascularization, we used the latter as the variable in the multivariable model because it showed the strongest association with survival (HR 0.31; $P = 0.001$). By multivariable Cox analysis, the completeness of revascularization was inversely related to the risk of death (HR 0.44; 95% CI 0.22–0.87; $P = 0.021$). Other variables independently related to death were age, LVEF, and CTO vessel.

The need for surgical coronary revascularization was more frequent in the CTO–PCI failure group when compared with the CTO–PCI success group (9.1 and 2%, respectively; $P < 0.001$).

Table 3 Clinical outcome

	CTO–PCI failure ($n = 142$)	CTO–PCI success ($n = 344$)	*P*-value
1-year MACCE			
Death, *n* (%)	17 (12)	17 (5)	0.006
Myocardial infarction, *n* (%)	0	3 (0.9)	0.264
Stroke, *n* (%)	0	3 (0.9)	0.264
CABG, *n* (%)	13 (9.1)	7 (2)	<0.001
CTO vessel re-PCI, *n* (%)	–	40 (12)	
Non-CTO vessel re-PCI, *n* (%)	18 (13)	50 (15)	0.591
Long-term cardiac survival			
Overall ($n = 486$), %	87.4 ± 2.9	91.6 ± 2.0	0.025
Single-vessel disease ($n = 70$), %	93.3 ± 6.4	93.6 ± 3.6	0.986
Multivessel disease ($n = 416$), %	86.6 ± 3.1	91.4 ± 2.2	0.021
Completeness of revascularization	Incomplete ($n = 185$)	Complete ($n = 301$)	
Overall ($n = 486$), %	83.8 ± 3.6	94.0 ± 1.7	<0.001

MACCE, major adverse cardiac and cerebrovascular events; CABG, coronary artery bypass grafting; CTO, chronic total occlusion; PCI, percutaneous coronary intervention.

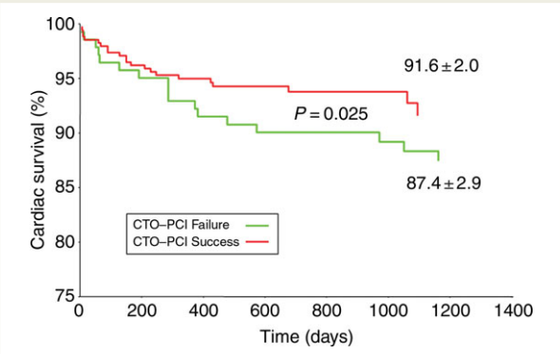

Figure 1 Kaplan–Meier analysis of cardiac survival in patients with chronic total occlusion (CTO)–percutaneous coronary intervention (PCI) success when compared to patients with CTO–PCI failure.

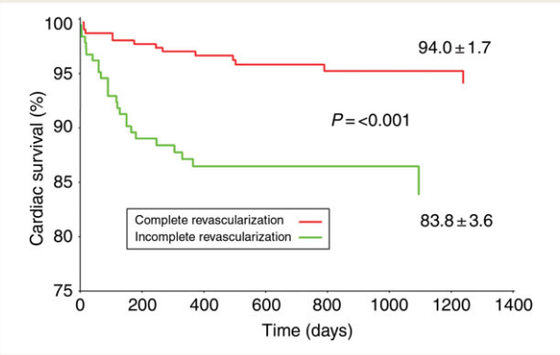

Figure 2 Kaplan–Meier analysis of cardiac survival in patients with complete revascularization when compared to patients with incomplete revascularization.

Conversely, repeat CTO–PCI was performed exclusively in the CTO–PCI success group (12%). The other major non-fatal adverse events included three MI and three ischaemic stroke. All these events occurred in the CTO–PCI success group.

In survivors with successful CTO–PCI, the LVEF at 6 months was significantly increased when compared with the baseline value (46.5 ± 11.3 vs. 42.2 ± 12.1%; $P < 0.001$; paired echocardiographic data were available for 290 patients).

The angiographic follow-up rate per successfully treated CTO was 82%. The patency rate was 88% while binary restenosis rate was 11.2%. Out of 32 patients with reocclusion, 15 had a stent length >50 mm, and 10 had a reference vessel diameter <2.5 mm.

There were no differences in target vessel revascularization (11.9 vs. 14.5%; $P = 0.538$) and angiographic restenosis rates (15.9 vs. 22.7%; $P = 0.226$) between patients who received sirolimus-eluting stent or paclitaxel-eluting stents, respectively.

Discussion

The current study shows that PCI success for CTO confers a 2-year survival benefit. Improvement in survival is driven by the differences in the outcome of patients with multivessel disease and who were completely revascularized, as compared to patients with incomplete revascularization owing to the failure of CTO–PCI. Patients with a single CTO and without angiographic significant disease in the other vessels had a very low mortality whatever the results of the PCI attempt. The completeness of revascularization was a strong independent predictor of survival, and by definition most patients who were completely revascularized had a successful CTO–PCI.

Successful PCI for CTO is associated with improvement in survival when compared with PCI failure in three studies,[3–5] while no survival benefit could be revealed in another one from the Mayo Clinic.[13] The only concluded randomized trial comparing medical therapy with PCI in patients with subacute total coronary occlusion,

Table 4 Predictors of cardiac mortality

	Univariable analysis		Multivariable analysis	
	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
Age (years)	1.08 (1.04–1.11)	<0.001	1.05 (1.01–1.08)	0.007
Previous MI	2.28 (1.17–4.43)	0.015	1.48 (0.74–2.96)	0.270
LVEF (%)	0.91 (0.89–0.94)	<0.001	0.93 (0.90–0.95)	<0.001
Completeness of revascularization	0.31 (0.16–0.61)	0.001	0.44 (0.22–0.87)	0.021
CTO vessel (reference indicator LAD)		0.004		0.036
RCA	0.28 (0.13–0.60)	0.001	0.37 (0.17–0.82)	0.014
LCx	0.49 (0.21–1.15)	0.103	0.55 (0.23–1.31)	0.177
Other vessel	0.21 (0.05–0.88)	0.034	0.25 (0.06–1.10)	0.067

CI, confidence interval; CTO, chronic total occlusion; HR, hazard ratio; LAD, left anterior descending artery; LCx, left circumflex; LVEF, left ventricular ejection fraction; MI, myocardial infarction; RCA, right coronary artery.

the Occluded Artery Trial (OAT),[14] has shown no clinical benefit at 2-year follow-up of revascularization when compared with medical therapy in asymptomatic or poorly symptomatic patients with subacute MI. However, most OAT patients had single-vessel disease and 93% underwent single-vessel PCI. There are no data from randomized studies assessing the impact of CTO revascularization on survival in patients with multivessel disease.

Several characteristics of the current study should be highlighted to put the results into a proper perspective and also to organize a comparison with the results of previous studies. The current study is based on a large cohort of consecutive patients with CTO (>3 months in duration) and most of them had multivessel disease and multivessel intervention supported by DES. Previous studies have included patients with a shorter duration of the occlusion also, and PCI was undertaken without the contemporary specialized technologies, including DES. It seems likely that the selection process of CTO with more favourable characteristics for PCI success used in previous studies was associated with the selection of patients with a better baseline cardiac risk profile when compared with the current study. Patients in the current study were several years older, and more frequently had LV dysfunction and multivessel intervention when compared with previous studies, and the current study shows that age, LVEF, and completeness of revascularization are independent predictors of survival. Moreover, all patients before PCI attempt had the evidence of viable myocardium in the territory of the occluded vessel by echographic or scintigraphic provocative tests. Thus, it is likely that the high-risk profile of the studied population made possible the demonstration of strong survival benefit of CTO–PCI success with a relatively small number of patients and short follow-up. Moreover, different from previous studies that used balloon angioplasty or bare metal stents, the routine use of DES in the current study resulted in maintaining a patency of the CTO vessel in most patients at the scheduled angiographic follow-up avoiding the confounding effect of silent CTO vessel reocclusion on clinical outcome. The patency rate of 88%, as revealed by the current study, is lower than reported by other studies using DES.[6,10] However, these studies also included CTO lasting <3 months, or shorter lesions when compared with patients of the current study.

Possible explanation of the clinical benefit of CTO revascularization survival include improvement in LV function in patients with viable myocardium, prevention, or slowdown of ventricular remodelling, decrease in electrical instability, and associated risk of fatal arrhythmic events, increased tolerance of future coronary occlusion events.[14–18] The mechanisms of the improved survival in patients with CTO–PCI success cannot be ascertained and are beyond the scope of the present study.

Study limitations

The study is a retrospective analysis and does not allow a comparison with other therapeutic strategies, such as conservative medical therapy or coronary surgery. We did not collect data about the adjunctive medical therapy in the two groups of patients with CTO–PCI success and CTO–PCI failure. However, it is unlikely that the two groups received different medical therapies considering that both were similar in all baseline characteristics but for age, and that most patients of the CTO–PCI failure had successful PCI of vessels other than CTO and received the same long-term antiplatelet treatment after PCI. However, despite these limitations, the study comprises a large cohort of patients with CTO–PCI attempt using contemporary techniques with a complete clinical follow-up, and the results show that percutaneous CTO revascularization is a valid therapeutic approach in patients with viable myocardium in the territory supplied by the CTO vessel. The results of the study do not support the routine PCI approach for all CTOs. First, we excluded patients with CTO and lack of evidence of viability in the territory supplied by the chronically occluded vessel from the study. Secondly, the same operator's skill should be considered as a prerequisite for the reproducibility of the results.

Conflict of interest: none declared.

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