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Review

Percutaneous revascularization of coronary chronic total occlusion: Toward a reappraisal of the available evidence

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ABSTRACT

Chronic total occlusion (CTO) is a challenging subset of coronary artery disease that is commonly encountered in real-world practice; it is associated with worse long-term prognosis. Observational studies suggest that percutaneous coronary intervention (PCI) for CTO is associated with reduction in myocardial ischemia and improvement in quality of life and left ventricular function. Some observational studies suggested that CTO-PCI is associated with improvement of the 'hard' clinical endpoints; others did not. Nearly all these studies compared the clinical outcome of successful versus failed PCI, rather than comparing the outcome of a whole CTO-PCI cohort versus a 'true' control group. Interestingly, in observational studies that compared the outcome of CTO-PCI versus optimal medical treatment, long-term mortality was comparable between the two strategies. In patients with multivessel disease and CTO, complete revascularization is more often achieved by coronary artery bypass grafting than by PCI; the SYNTAX score of these patients often favors surgical revascularization according to the current guidelines. The current guidelines reflect the divergence of opinion on the usefulness/benefit of CTO-PCI, mainly due to the lack of randomized trials. Evidence is awaited from three ongoing randomized controlled trials comparing PCI versus optimal medical treatment in the setting of CTO.

Contents

Introduction

Defined as 100% coronary occlusion with Thrombolysis in Myocardial Infarction grade 0 distal flow persistent for >3 months, chronic total occlusion (CTO) is commonly encountered in clinical practice. In North American reports, the prevalence of CTO ranged from 18.4% in patients with significant coronary artery disease who underwent elective coronary angiography, to 31% in all patients who underwent coronary angiography not including coronary artery bypass grafting (CABG); the prevalence ranged from 16% to 19% in the CERDO-Kyoto Registry cohort-2 from Japan [1–3]. In the European STAR Registry the prevalence was 33% in stable patients undergoing first diagnostic angiography; in this registry, CTO was

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associated with higher 1-year mortality (attributed to confounders, such as diabetes and left ventricular dysfunction) [4]. Comparably, in the Italian Registry of Chronic Total Occlusion (IRCTO), the prevalence of patients with ≥1 CTO was 12.3% [5]. Patients with ≥1 CTO have worse prognosis, even after revascularization of another vessel territory. CTO of a non-infarct-related artery independently predicted long-term mortality in patients who underwent primary percutaneous coronary intervention (PCI) for ST-elevation myocardial infarction (MI) [6,7]. In patients with 3-vessel disease who presented with non-ST-elevation MI, CTO of a non-infarct-related artery was independently associated with 12-month mortality [8].

Collaterals to CTO

Long-standing CTO is usually accompanied by the development of collaterals. Viability in the CTO territory is not a prerequisite for collateral formation: in 47 patients with CTO, collaterals predicted viability with modest sensitivity and specificity (75% and 65.7%) [9]. Although, theoretically, collaterals prevent myocardial necrosis and secure metabolic needs for resting contractile function in the CTO territory, evidence suggests that collaterals are insufficient to prevent baseline ischemia or to provide adequate flow during increased needs. In 50 symptomatic patients who underwent CTO-PCI, resting ischemia was present (fractional flow reserve <0.08) in 78% of the patients, even with well-developed collaterals [10]. Increased collateral flow under pharmacological stress was observed in only 7% of patients with CTO without prior MI ($n = 62$); coronary steal occurred in 36%; neither collateral flow reserve nor coronary steal was related to the extent of regional contractility [11]. Furthermore, in 21 patients with non-revascularized CTO, collaterals (61%) failed to predict cardiac events (23 months follow-up) or freedom from ischemia on myocardial perfusion imaging (MPI); ischemia on MPI predicted events in these patients [12]. In view of the small sample size and the limitation of retrospective design, the latter results should be taken with caution.

What do the proponents of percutaneous revascularization say?

Traditionally, CTO represents a challenging subset for the interventional cardiologist; CTO-PCI has been associated with low success rates and high complication rates [13–16]. Yet, important developments in the field including dedicated equipment and sophisticated techniques have triggered growing interest in CTO-PCI [17]. In observational studies, successful CTO-PCI was associated with improvement in quality of life, surrogate endpoints, and cardiovascular outcome.

Improvement of quality of life

In observational studies, successful, versus failed, CTO-PCI was associated with greater improvement in quality of life parameters, at short- and long-term follow-up (Table 1) [18–20]. Improvement in quality of life parameters was reported after CTO revascularization (PCI or CABG) at 1 year, compared with baseline; no such improvement occurred with medical treatment [21]. Moreover, improvement in quality of life was comparable between CTO-PCI and non-CTO-PCI [22].

Improvement in the surrogate endpoints

Observational studies demonstrated improvement in global and regional left ventricular function in patients who underwent

Table 1
Studies of quality of life following CTO-PCI.

Study	Ref.	Center	No. of patients	Success rate	Comparison groups	Evaluation	Follow-up duration	Adjustment	Results
Borgia et al.	[18]	Single-center	302	78%	Successful versus failed CTO-PCI	SAQ-UK	4 years	Yes	Improvement of physical limitation, angina frequency, and treatment satisfaction in successful versus failed CTO-PCI
Grantham et al.	[19]	Multi-center	125	55%	Successful versus failed CTO-PCI	SAQ	1 month	Yes	Improvement of physical limitation, angina frequency, and QOL in successful versus failed CTO-PCI, more in symptomatic patients
Ciećwierz et al.	[20]	Single-center	276 (1:1 matched pairs)		Successful versus failed CTO-PCI	Angina symptoms	6 months and 2 years	Yes	Greater improvement of angina burden, and more resolution of angina in successful versus failed CTO-PCI, both at 6 months and 2 years
Wijeysundera et al.	[21]	Multi-center	387 (only 46 underwent PCI)	78.8%	Treatment groups (PCI, CABG, MT) were compared with baseline	SAQ	1 year		Improvement of physical limitation, angina frequency, angina stability, disease perception, treatment satisfaction, and EQ5D in patients who underwent revascularization by PCI and CABG at follow-up, compared with baseline; no improvement in MT group
Safley et al.	[22]	Multi-center	147	85% (CTO-PCI) 98% (non-CTO-PCI)	CTO-PCI versus non-CTO-PCI	SAQ	6 months	Yes	Comparable improvement of physical limitation, angina frequency, EQ5D, QOL, and Rose Dyspnea Score in successful CTO-PCI and successful non-CTO-PCI

CABG, coronary artery bypass grafting; CTO, chronic total occlusion; EQ5D, European quality of life-5 dimensions; MT, medical treatment; PCI, percutaneous coronary intervention; QOL, quality of life; SAQ, Seattle Angina Questionnaire.

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