

Utility of CT Coronary Angiography for Planning CTO Intervention

CTCA shows promise as an important modality in treating this challenging subset.

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Chronic total occlusions (CTOs) are a final frontier for interventional cardiology. Success rates for percutaneous coronary intervention (PCI) are lower for CTO than for any other indication: >80% in most series.¹ Several factors contribute to failed PCI in this setting, including duration of occlusion, length of occlusion, blunt stump of occlusion, and the presence of bridging collaterals.¹⁻⁶ While the importance of some of these angiographic characteristics has been questioned, other interventionalists have asked, "Is there a better way to predict success in the revascularization of CTO than with conventional angiography?"

IMPORTANCE OF CTO

Despite the fact that CTO intervention accounts for 10% of all coronary revascularization procedures, data are not yet clear about procedural and clinical outcomes among these patients. Most of the available data are limited by retrospective, observational designs. Successful CTO percutaneous revascularization

decreases anginal frequency and the need for coronary artery bypass grafting surgery.⁴ Data also suggest improved survival and survival free from nonfatal myocardial infarction in successful CTO revascularization.^{4,7} Therefore, predicting which patients would have successful PCI of a CTO is of definite importance.

EVIDENCE FOR CTCA IN CTO INTERVENTION

Multiple imaging modalities are now available to cardiologists for imaging CTO.⁸ CT coronary angiography (CTCA) is proving useful for planning many invasive

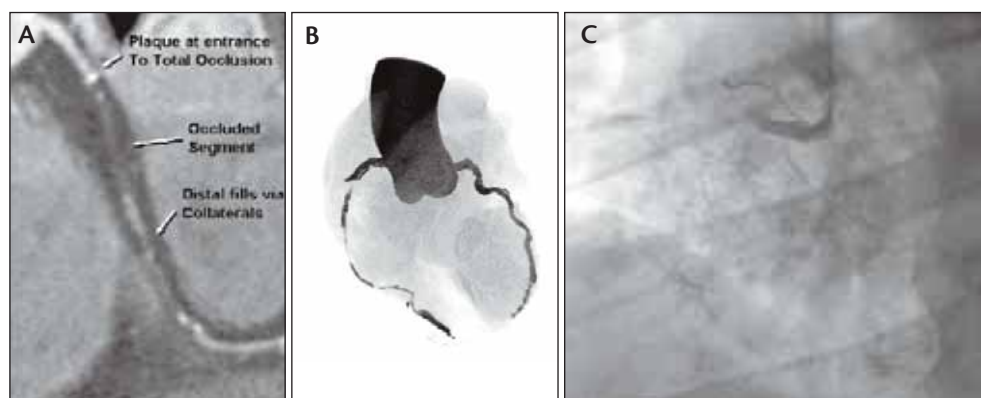


Figure 1. CTA of a chronically occluded right coronary artery. The occluded segment, beginning with a calcific plaque and a midvessel noncalcified plaque. The distal portion of this vessel fills via collateralization and is of lower intensity (A). CTA in an "angiographic equivalent" mode shows angiographic simulation of how this lesion and vessel would appear angiographically after recanalization (B). The angiogram for this patient with a total occlusion of the proximal right coronary artery (C).

TABLE 1. ANGIOGRAPHIC AND MSCT CORONARY MULTIVARIATE PREDICTORS OF PROCEDURAL FAILURE FOR CHRONIC TOTAL OCCLUSION^a

Variable	Coefficient	Wald's Chi-Square	DF	P Value	OR (95% CI)
Clinical/angiographic predictors					
Occlusion duration >9 mo	1.27	3.3	1	.07	3.56 (0.91–4.02)
Tapered stump	-1.93	7.46	1	<.01	0.15 (.04–0.58)
Constant	0.24	0.13	1	.7	
MSCT coronary angiography predictors					
Occlusion length >15 mm	1.86	5.21	1	.02	6.39 (1.3–31.41)
Severe calcification	2.49	6.51	1	.01	12.01 (1.78–81.1)
Stump morphology		5.63	2	.06	
Blunt	1				
Tapered	-2.19	5.23	1	.02	0.11 (.02–0.73)
Not determinable	-2.65	3.46	1	.06	.07 (0–1.15)
Constant	-0.45	0.26	1	.6	
Clinical/angiographic + MSCT coronary angiographic predictors					
Tapered stump	-2.43	7.98	1	<.01	.09 (.02–0.48)
Occlusion length >15 mm	2.17	6.16	1	.01	8.77 (1.58–48.76)
Severe calcification	2.03	5.18	1	.02	7.62 (1.33–43.74)
Constant	-0.67	0.74	1	.4	

Abbreviations: CI, confidence interval; DF, degrees of freedom; MSCT, multislice computed tomography; OR, odds ratio.
^aAdapted from Mollet NR, Hoyer A, Lemos PA, et al. Value of preprocedural multislice computed tomographic coronary angiography to predict the outcome of percutaneous recanalization of chronic total occlusions. *Am J Cardiol.* 2005;95:240–243.⁹

cardiac procedures, particularly complex PCI procedures, including CTO and bifurcation stenting.^{9–11} CTCA is becoming the “go-to” imaging modality for CTO planning. CTCA offers the interventional cardiologist a clear view of the CTO in question. Specifically, it allows a distinct and accurate measurement of CTO length and visualizes proximal and distal segments near the occlusion (Figure 1). In a report of 47 CTO lesions evaluated by CTCA and conventional angiography, Mollet et al reported measuring CTO length accurately in all patients by CTCA compared to only eight of 47 (17%) by conventional angiography. They also showed the prognostic significance of the ability to measure the

length of the CTO; a CTO lesion length >15 mm as determined by CTCA portended a high rate of PCI failure (odds ratio [OR], 6.39) (Table 1).⁹

CTCA has additional benefits in CTO planning beyond improved preprocedural visualization. The Mollet study showed three factors from CTCA with independent predictive value for PCI success or failure in CTO, whereas conventional angiography showed only one (Table 1).⁹ The cohort consisted of 45 patients referred for percutaneous recanalization of CTO lesions who underwent CTCA within 53 days of the PCI attempt. Readers of both the conventional angiograms and the multislice CT scans were blinded to the results

TABLE 2. ABSOLUTE AND RELATIVE CONTRAINDICATIONS FOR CORONARY CTA^a

Contraindication	Description
Absolute relative	• Hypersensitivity to iodinated contrast agent • History of allergies or allergic reaction to other medications • Renal insufficiency (serum creatinine level of >1.5 mg/dL) • Congestive heart failure • History of thromboembolic disorders • Multiple myeloma • Hyperthyroidism • Pheochromocytoma • Atrial fibrillation • Inability to perform breath hold for 15 seconds

^aAdapted from Hoffman U, Ferenick M, Cury R, et al. Coronary CT angiography. J Nucl Cardiol. 2006;47:797-806.¹³

of the other modality. The authors evaluated parameters similar to those of conventional angiography: a blunt rather than tapered stump, severe calcification (defined as the presence of high-density plaques ≥ 130 HU), a side branch at the occlusion site, proximal tortuosity, and occlusion length. All operators were experienced interventional cardiologists. The results are shown in Table 1.

Using conventional angiography, only a tapered stump showed significant predictive success for PCI (OR of PCI failure, 0.15 [.04–0.58]; $P < .01$). CTCA also showed a tapered stump as favorable (OR of PCI failure, 0.11 [.02–0.73]; $P = .02$) but also showed an occlusion length >15 mm and severe calcification as strong independent predictors of PCI failure in CTO (OR of PCI failure, 6.39 [1.3–31.41]; $P = .02$ for occlusion length >15 mm; OR, 12.01 [1.78–81.1]; $P = .01$ for severe calcification). The authors note that despite radiation doses ranging from 6 to 13 mSv, CTCA was a useful test that optimized therapeutic strategy and that could lead to shorter procedures.⁹ In a hypothetical patient with severe calcification, a blunt stump, and lesion length >15 mm, CTCA may help avoid an unsuccessful PCI attempt altogether.

Severe calcification as a predictor of PCI failure in CTO lesions has been further validated. Soon et al conducted a prospective observational study on 39

patients (43 CTO lesions) and found a PCI success rate of 55.8% (24 of 43).¹⁰ Transluminal lesion calcification (>50%) on CTCA was the only statistically significant determinant of failed PCI after multivariate analysis (OR of PCI success, 0.1 [.02–0.47]; $P = .003$). A blunt stump seen on conventional angiography was also associated with failed PCI (OR, 0.24 [.07–0.86]; $P = .029$ by univariate analysis), although this was not statistically significant after multivariate analysis (OR, 0.22 [.03–1.82]; $P = .16$ by multivariate analysis). There was no evidence suggesting that the duration of CTO, the presence of bridging collaterals or side branches, nor the absence of microchannels (as assessed by conventional angiography) predicted PCI failure.¹⁰

LIMITATIONS OF CTCA AND OTHER CONSIDERATIONS

CTCA has undergone rapid growth in the past several years. Currently, 64-slice (or higher) CT scanners are in common use and are being replaced by faster and higher-resolution units. As techniques improve, the main relative contraindications to CTCA (radiation exposure and arrhythmia/high heart rates) will be further minimized. Other relative contraindications noted by Hoffman et al are shown in Table 2.¹³ Some of the listed contraindications are rare; others are likely relative contraindications to invasive angiography.

Efforts to decrease radiation exposure for CTCA are underway and appear promising. The consideration of radiation exposure merits extra attention in the situation of CTOs, because giving a patient radiation before invasive angiography seems like a “double-whammy.” However, there is evidence that not only advanced scanner technology, but also techniques such as prospective gating, may significantly reduce radiation exposure. Additionally, as noted earlier, having the additional information and the ability to predict procedural success and technique may save radiation and dye exposure in the catheterization lab.

Prospective gating has proven able in acquiring good quality images while simultaneously limiting radiation exposure. Standard chest x-rays expose patients to approximately .04 mSv, and yearly background radiation exposure is 3 mSv. Current scanning techniques now limit radiation doses to under 5 mSv.

SUMMARY

CTCA is rapidly emerging as an important component to CTO planning. Several prospective studies clearly show an association of heavy lesion calcification and PCI failure, as determined by CTCA. Additionally, a

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blunt stump on both CTCA and conventional angiography is a poor prognostic sign for PCI success. Finally, CTCA offers an accurate assessment of CTO lesion length, which also appears to be related to procedural success (less success if lesion length is >15 mm).

CTCA appears to be even better at predicting PCI success (or failure) in CTO than traditional coronary angiography. Given the rapid growth of CT technology and the clinical outcomes data, one can expect the use of CTCA to play an even larger role in CTO intervention in the future. ■

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