JACC: CARDIOVASCULAR INTERVENTIONS
VOL. 2, NO. 9, 2009

ISSN 1936-8798/09/$36.00
PUBLISHED BY ELSEVIER INC.
DOI: 10.1016/j.jcin.2009.06.011

EDITORIAL COMMENT

Import and Export of Interventional Technique

Something to Declare at the Border*

David E. Kandzari, MD

La Jolla, California

Despite their prevalence in approximately one-third of diagnostic coronary angiograms (1), chronic total coronary occlusions (CTO) remain a dilemma for the practice of interventional cardiology. Against the background of a historically stagnate approximately 70% technical success rate for guidewire recanalization (2,3), the overall frequency of attempted percutaneous CTO revascularization has not considerably changed within the past decade (4). Even with the successes achieved in a contemporary era of percutaneous coronary intervention (PCI), perceptions (and misperceptions) regarding patient selection, procedural success, and late-term benefit enable clinicians to justify the presence of a CTO as a rationale for medical therapy alone, a referral to bypass surgery, or least commonly as a case for percutaneous revascularization.

See page 834

As an example of the reluctance to attempt PCI for this lesion complexity, the frequency of CTOs was 4 times more common in the recent SYNTAX (SYNergy between PCI with TAXUS and Cardiac Surgery) surgical registry compared with the randomized trial (5). Nonetheless, still more than 90% of CTOs were attempted in patients randomized to PCI, and conversely, more than 30% of CTOs were not surgically revascularized for reasons that included an unsuitable distal target or simply operator's discretion (6). Thus, successful CTO revascularization by referral to bypass surgery does not occur by intention to treat alone.

Although there remains a rationale for the "late open artery hypothesis," clinical arguments for or against CTO revascularization are assisted by a less than complete evidence basis. Although limited by observational design, percutaneous CTO revascularization is supported by a remarkable consistency across several clinical trials associating procedural success with improved late-term survival compared with those patients for whom CTO recanalization was not achieved (7–11). A purpose for CTO PCI seems also reinforced by additional studies associating avoidance of CTO treatment with incomplete revascularization and its adverse clinical consequences (11,12).

Aside from the potential for improved late outcome, more immediate benefits of successful CTO revascularization include improved left ventricular function, decreased ischemic burden and associated symptoms, tolerance for future ischemic events, and possibly reduced predisposition for arrhythmic events (1). Despite the intuitive benefit of an open artery, however, no prospective randomized trial of CTO revascularization has ever been performed (or seems near), and the rationale for CTO PCI is challenged by a singular trial demonstrating no clinical benefit with revascularization of subacute total occlusions after recent myocardial infarction (13). Differences in the indication and pathophysiology notwithstanding, it is noteworthy that—unlike the clinical characteristics of patients included in the OAT (Occluded Artery Trial)—CTO patients selected for attempted PCI often represent a very different patient population, characterized by symptoms refractory to medical therapy, abnormal left ventricular function, multivessel coronary disease, and/or extensive ischemia demonstrated by noninvasive testing. Performance of CTO revascularization on the basis of these indications is also in accord with recent multidisciplinary committee recommendations regarding appropriateness of PCI in specific patient and lesion subsets (14).

In parallel with outcomes data indicating benefit after CTO revascularization and the successes of drug-eluting stents in maintaining target vessel patency is the stark reality that any potential advantage of CTO PCI is handicapped from the outset by the commonality of procedural failure, representing something more akin in magnitude to Achilles' leg than his heel. For instance, in spite of the frequency of attempted CTO PCI applying contemporary technical skills within the SYNTAX trial, procedural success was only achieved in 49% of lesions (6), and until recently, there was little indication by way of technique or technology that could seemingly improve rates of recanalization.

Apart from a variety of novel but ultimately disappointing technologies for crossing occluded coronary segments, specialized coronary guidewires remain the mainstay instrument in the CTO toolbox. Although CTO-specific guidewire technology itself has evolved considerably, a more revolutionary advancement has related to the technical skills and strategies regarding how these tools are used. In particular, the performance of sophisticated antegrade and retrograde guidewire manipulations introduced by Japanese interventionalists (15–17) and advanced throughout Asia and Europe have captivated audiences during live case

*Editorials published in *JACC: Cardiovascular Interventions* reflect the views of the authors and do not necessarily represent the views of *JACC: Cardiovascular Interventions* or the American College of Cardiology.

From the Scripps Clinic, Division of Cardiovascular Diseases, La Jolla, California. Dr. Kandzari has consulted for and received research/grant support from Cordis Corporation and Medtronic Vascular.

presentations and have been uniformly met with a combination of intrigue, amazement, and speculation. What new complications might these novel techniques introduce? Without any standard means to describe case selection, procedural success, and safety, are these outcomes generalizable to the broader, international cardiology community with more variable experience and skill set? Altogether, how might interventionalists navigate a steep and narrow learning curve to develop these skills in a North American clinical practice with differing culture regarding risk tolerance and standards of care?

In this issue of *JACC: Cardiovascular Interventions*, Thompson et al. (18) report procedural outcomes among 636 consecutive patients undergoing attempted CTO percutaneous revascularization at 2 institutions. Among the 12 operators, 2 interventionalists were experienced with both antegrade and retrograde guidewire techniques compared with "antegrade only" proceduralists. Acknowledging potential for unmeasured biases that might influence case selection and procedural outcomes, the study is further limited by the absence of details regarding patient indications and clinical outcomes beyond the index procedure. Procedural outcomes were also not independently adjudicated, considering the interest in detailing as much as possible regarding angiographic and clinical adverse events related to this advanced technique; nor were standard definitions of myocardial infarction applied. Nevertheless, the salient findings are that: 1) incorporation of retrograde techniques for CTO PCI is possible in North American clinical practice; 2) retrograde CTO revascularization strategies seem to substantially improve procedural success rates compared with historical standards; 3) adverse safety events are similar between antegrade and retrograde techniques; 4) skills learned by retrograde operators also inform procedural success with the traditional antegrade approach; and 5) proficiency in the retrograde technique requires substantial learning and sustained experience.

The study by Thompson et al. (18) also suggests a model for describing systematic, measured adoption of complex procedural techniques directed toward complex anatomy. Pioneering methods may be: 1) shared through live case demonstrations, on-site didactic training and proctoring, Internet, and other media sources; 2) adopted selectively into practices; and 3) overall advance cardiovascular medicine by offering treatment options to patients previously without an alternative. The retrograde technique is 1 of many recent examples of interventional cardiologists' commitment to innovate, examine, and disseminate the practical aspects of evolving techniques so that they may be safely and effectively assimilated within the global interventional community.

As the investigators note, however, education regarding the retrograde approach requires extensive training over years rather than short term. Complexities of the retrograde technique extend well beyond guidewire manipulation (e.g., intravascular ultrasound, guiding catheter support technique), and it is likely for this reason that parallel advances in antegrade success were also observed. In part representing the effort required to learn these skills, only 2 of the 12 interventionalists performed the retrograde technique, yet all operators must be credited for submitting their individual outcomes as a quality and performance initiative within their programs.

The refinement of technique and advancing success in percutaneous CTO revascularization indicate that the pursuit of an open artery is anything but quixotic. Performance of advanced methods has in many instances overcome the historical predictors associated with CTO procedural failure (e.g., CTO length, calcification, sidebranch involvement) (16). Even so, not all CTO procedures are successful. New CTO techniques introduce new challenges and complications (e.g., collateral channel dilation and perforation). With the retrograde technique, still only approximately 75% of collateral channels may be traversed with a guidewire (16), and failure to do so is expectedly the greatest determinant of failure. Primary retrograde crossing is therefore successful in <70% of attempts without additional controlled dissection and/or antegrade wire techniques (16,17). It is uncertain then whether the retrograde approach should be considered a default for instances of failed antegrade recanalization or as a primary strategy in selected cases. And not all interventional cardiologists will learn these advanced methods. While there remains opportunity for improvement, the import of innovative techniques that might safely improve outcome in a lesion complexity termed the "last great barrier to PCI success" is welcomed.

Acknowledgment

The author expresses gratitude to Dr. Christopher Buller for his editorial review.

Reprint requests and correspondence: Dr. David E. Kandzari, S1056, 10666 North Torrey Pines Road, La Jolla, California 92037. E-mail: kandzari.david@scrippshealth.org.

REFERENCES

1. Stone GW, Kandzari DE, Mehran R, et al. Percutaneous recanalization of chronically occluded coronary arteries: a consensus document: Part I. Circulation 2005;112:2364–72.
2. Prasad A, Rihal CS, Lennon RJ, Wiste HJ, Singh M, Holmes DR. Trends in outcomes after percutaneous coronary intervention for chronic total occlusions: a 25-year experience from the Mayo Clinic. J Am Coll Cardiol 2007;49:1611–8.
3. Stone GW, Colombo A, Teirstein PS, et al. Percutaneous recanalization of chronically occluded coronary arteries: Procedural techniques, devices, and results. Cathet Cardiovasc Intervent 2005;66:217–36.
4. Christofferson RD, Lehmann KG, Martin GV, Every N, Caldwell JH, Kapadia SR. Effect of chronic total coronary occlusion on treatment strategy. Am J Cardiol 2005;95:1088–91.

5. Serruys PW, van Geuns RJ. Arguments for recanalization of chronic total occlusions. J Am Coll Card Intv 2008;1:54–5.
6. Serruys PW. SYNTAX Trial: Chronic Total Occlusion Subsets. Presented at: Cardiovascular Research Technologies 2009; Washington, DC; March 4, 2009.
7. Suero JA, Marso SP, Jones PG, et al. Procedural outcomes and long-term survival among patients undergoing percutaneous coronary intervention of a chronic total occlusion in native coronary arteries: a 20-year experience. J Am Coll Cardiol 2001;38:409–14.
8. Ramanathan K, Gao M, Nogareda GJ, et al. Successful percutaneous recanalization of a non-acute occluded coronary artery predicts clinical outcomes and survival. Circulation 2001;104:II415.
9. Olivari Z, Rubartelli P, Piscione F, et al. Immediate results and one-year clinical outcome after percutaneous coronary interventions in chronic total occlusions: data from a multicenter, prospective, observational study (TOAST-GISE). J Am Coll Cardiol 2003;41:1672–8.
10. Hoye A, van Domburg RT, Sonnenschein K, Serruys PW. Percutaneous coronary intervention for chronic total occlusions: the Thoraxcenter experience 1992–2002. Eur Heart J 2005;26:2630–6.
11. Valenti R, Migliorini A, Signorini U, et al. Impact of complete revascularization with percutaneous coronary intervention on survival in patients with at least one chronic total occlusion. Eur Heart J 2008;29:2336–42.
12. Hannan EL, Racz M, Holmes DR, et al. The impact of completeness of revascularization on long-term outcomes in the stent era. Circulation 2006;113:2406–12.
13. Hochman JS, Lamas GA, Buller CE, et al. Coronary intervention for persistent occlusion after myocardial infarction. N Engl J Med 2006; 355:2395–407.
14. Patel MR, Dehmer GJ, Hirshfeld JW, et al., for the Coronary Revascularization Writing Group. ACCF/SCAI/STS/AATS/AHA/ASNC 2009 appropriateness criteria for coronary revascularization: a report by the American College of Cardiology Foundation Appropriateness Criteria Task Force, Society for Cardiovascular Angiography and Interventions, Society of Thoracic Surgeons, American Association for Thoracic Surgery, American Heart Association, and the American Society of Nuclear Cardiology. J Am Coll Cardiol 2009;53: 530–53.
15. Surmely JF, Katoh O, Tsuchikane E, et al. Coronary septal collaterals as an access for the retrograde approach in the percutaneous treatment of coronary chronic total occlusions. Cathet Cardiovasc Interv 2007; 69:826–32.
16. Rathore S, Katoh O, Matsuo H, et al. Retrograde percutaneous recanalization of chronic total occlusion of the coronary arteries: procedural outcomes and predictors of success in contemporary practice. Circ Cardiovasc Interv 2009;2:124–32.
17. Saito S. Different strategies of retrograde approach in coronary angioplasty for chronic total occlusion. Cathet Cardiovasc Interv 2008;71: 8–19.
18. Thompson CA, Jayne JE, Robb JF, et al. Retrograde techniques and the impact of operator volume on percutaneous intervention for coronary chronic total occlusions: an early U. S. experience. J Am Coll Cardiol Intv 2009;2:834–42.

Key Words: chronic total occlusion ■ retrograde technique ■ procedural outcomes.