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EDITORIAL COMMENT

The Safety and Outcomes of Chronic Total Occlusion Interventions*

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The percutaneous treatment of chronic total occlusions (CTO) is often viewed as one of the remaining frontiers of interventional cardiology. It remains a challenging procedure, associated with increased risk of significant complications. Chronic total occlusions are present in approximately 15% of patients referred for cardiac catheterization and in approximately 23% of those with multivessel or left main disease, and attempted percutaneous revascularization rates are low at approximately 13% (1,2). In addition, many cardiologists favor medical therapy of these lesions with referral for coronary artery bypass grafting (CABG) for refractory symptoms, because these lesions are by

See page 128

definition categorized as stable coronary artery disease. Therefore, they consider CTO patients in the same group as those treated in the COURAGE (Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation) trial (3). This approach has recently been challenged by a meta-analysis of 7,182 patients with stable coronary artery disease comparing optimal medial therapy and percutaneous coronary intervention (PCI), which found greater angina relief both short- and long-term (4). More importantly, in the COURAGE trial, those with moderate to large regions of ischemia demonstrated a survival benefit with percutaneous treatment (5).

Reasons to pursue percutaneous revascularization of CTOs include the potential for a reduction in angina symptoms, improved quality of life and functional status, a reduced need for CABG, and better long-term survival (1,6,7). A recent meta-analysis by Joyal et al. (7) addressed outcomes of patients who underwent successful versus unsuccessful CTO intervention. Although no randomized trials were found, 13 observational studies comparing PCI with planned medical therapy were included. This analysis demonstrated a survival benefit for those who underwent recanalization (14.3% vs. 17.5%, odds ratio [OR]: 0.56). There was a reduction in need for subsequent CABG (OR: 0.22) and, in the 6 studies that reported angina status, a reduction in residual/recurrent angina (OR: 0.45). In addition, in those patients with left ventricular dysfunction and demonstrated viability in the region of the CTO, recanalization might improve left ventricular function and regional wall motion (8,9). Despite the common perception that well-developed collaterals are protective, collateral flow reserve assessment has demonstrated that collateral flow is usually inadequate to prevent ischemia during stress (10).

Potential explanations for the improved survival in those undergoing recanalization include improvement in left ventricular function, reduced predisposition to ventricular arrhythmias, or improved survival in the setting of an acute myocardial infarction due to occlusion of another vessel (1). Thus, consensus documents recommend consideration of CTO PCI if the patient is symptomatic from the CTO (or if a large region of ischemia/viability is present), the myocardium supplied is viable, the likelihood of success is >60%, and the anticipated major complication rate is low (11–13).

The interventional approach to CTOs is rapidly evolving, with an increasing emphasis on dedicated operator and staff training, development of CTO centers, and flourishing training courses and CTO clubs. Operator training, experience, and technique are crucial for procedural success and minimization of complications (14). In a registry of 636 CTO procedures, those operators with experience and frequent use of the retrograde technique had a significantly greater technical success rate compared with low-volume CTO operators (75.2% vs. 58.9%, $p < 0.0001$) (14). Thus, a detailed understanding is required of guide catheter use, wire selection, wire re-entry techniques, antegrade and retrograde approaches, and specialist equipment (15).

In this issue of *JACC: Cardiovascular Interventions*, Patel et al. (16) report a meta-analysis of registries and case series describing procedural complications of CTO PCI and demonstrate high technical success with low complication rates. We know from the Japanese experience that CTO PCI can be performed safely with high success rates, but this is the first meta-analysis to address complications in a broader range of centers. An experience of 18,071 patients undergoing PCI of 18,941 CTO lesions is described. It is striking that, in a wider array of procedural experience, the success rate is high at 77%, with low rates of death, emergent CABG, and stroke. Additionally, with 886 lesions treated with a retrograde approach, the success rate was 79.8% with no deaths and low risk of emergent CABG and tamponade. Of note, those who underwent an unsuccessful CTO PCI attempt had higher rates of death, stroke,

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coronary perforation, and tamponade. This is not unexpected, given that CTO PCI often requires the use of aggressive wires that can cause dissection and perforation and cannulation of collateral vessels that can cause ischemia and loss of collateral flow.

These are promising results, demonstrating safe and effective expansion of complex techniques beyond a few isolated centers. Still, operator CTO volume and experience play a large role in outcomes (14), and—as the authors indicate—individual operator experience is not available for this particular analysis. To address the issue of operator volume, the authors used case series as a surrogate for operator volume and did not find a difference in outcomes between small series and large ones. However, as they point out, some of the small case studies were reported by groups known to have a high CTO volume; thus this is a poor surrogate. Additionally, publication bias is particularly an issue in an analysis such as this, in that those with poor results are less likely to report their outcomes. Nevertheless, we know that CTO interventions can be performed safely with a high rate of technical success, supporting the expansion of these procedures to those centers willing to make the commitment of training and meticulous technique required for these challenging procedures.

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Key Words: chronic total occlusion ■ collateral flow ■ percutaneous revascularization.