Update on the Management of Chronic Total Occlusion of Coronary Arteries: Review Article

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Abstract:

Chronic complete occlusions (CTOs) are observed in roughly one-third of individuals with coronary artery disease (CAD) and can be difficult to treat during percutaneous revascularization. Advances in CTO percutaneous coronary intervention (PCI) procedures, devices, and algorithms, on the other hand, have resulted in major improvements in the successful treatment of CTOs. This review covers existing CTO management in light of recent PCI approaches and evidence.

Keywords: CTO, Coronary Artery, PCI.

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Introduction:

A coronary chronic complete occlusion (CTO) is defined as angiographic evidence of 100% blockage of a coronary artery for more than or equal to 3 months. The TIMI flow grading system (thrombolysis in myocardial infarction) is a score system from 0 to 3 that refers to the levels of coronary blood flow determined during coronary angiography. The TIMI flow grading system is as below ***(1, 2)***:

- TIMI 0 flow (no perfusion-complete occlusion)- no forward flow beyond a coronary blockage.
- TIMI 1 flow (penetration without perfusion)- weak forward flow beyond the blockage due to partial filling of the distal coronary bed.
- TIMI 2 flow (partial reperfusion) - delayed forward flow with complete distal coronary bed filling.
- TIMI 3 flow (full perfusion) - normal flow that completely fills the distal coronary bed.

Risk Factors

Risk factors for CTO lesion in patients are as below ***(3)***:

- A history of myocardial infarction or known coronary artery disease.
- Tobacco usage excessively
- High LDL cholesterol, low HDL cholesterol
- Diabetes
- Sedentary lifestyle
- Hypertension
- Premature sickness in the family
- End-stage kidney disease, obesity, and postmenopausal women are all risk factors.

Epidemiology

CTO lesions are identified in one-quarter to one-third of patients who have diagnostic coronary angiography. The true frequency in the general population, however, is unknown because a fraction of individuals with CTO lesions are asymptomatic or mildly symptomatic and never get definitive coronary angiography. Patients having a history of coronary artery bypass graft surgery are more likely to suffer CTOs in their native vessels (50% to 55%) ***(4)***.

CTO lesions are most common in the right coronary artery and least common in the left circumflex artery, according to data from the National Heart, Lung, and Blood Institute (1997-1999) Dynamic Registry. Older patients are more likely to have at least one CTO lesion, with 37% prevalence in patients under the age of 65, 40% in patients aged 65 to 79 years, and 41% in those aged 85 and over ***(5)***.

Pathophysiology

Multiple mechanisms contribute to the pathogenesis of coronary artery disease, which can proceed to CTO lesions, including elevation of immunologic and inflammatory markers (cytokines, leukocytes, high sensitivity C-reactive protein), endothelial dysfunction, and cholesterol accumulation. Most typically, it begins with the accumulation of smooth muscle cells inside the intima, which advances to the accumulation of macrophages within the intima, resulting in pathologic intimal thickening and the advancement of lesions ***(6)***.

Histopathology

Calcium, lipids (both intracellular and extracellular), smooth muscle cells, an extracellular matrix, and neovascularization are frequent histopathological characteristics of a CTO lesion. Occlusions often feature a dense concentration of collagen-rich fibrous tissue at the proximal and distal ends, contributing to a columnar lesion of calcified, tough fibrous tissue around a softer core of organized thrombus and lipids. Lesion types are classified as soft, hard, or a combination of the two. Soft plaques, which are composed of cholesterol-laden cells and foam cells, are more common in occlusions younger than 12 months old. Hard plaques are more common in earlier

occlusions and are distinguished by dense fibrous tissue with fibrocalcific areas but no neovascular channels *(7)*.

Diagnosis:

CTO lesions are discovered in individuals having coronary angiography to rule out ischemic heart disease, cardiomyopathy, or valvular heart disease. Ischemic heart disease symptoms include conventional chest pain (stable or unstable angina), unusual chest pain, NSTEMI, or STEMI. Patients with various types of cardiomyopathies or valvular heart disease, on the other hand, may present with a variety of symptoms, including decompensated congestive heart failure. As a result, when obtaining a history in patients suspected of having ischemic heart disease, it is critical that they describe and subjectively assess their symptoms *(8)*.

Risk factors for cardiovascular disease (diabetes, tobacco use, hypertension, hyperlipidemia) and non-cardiac causes of the patient's symptoms, such as pulmonary embolism, aortic dissection, pneumothorax, esophageal rupture, or perforating peptic ulcer, should also be included in the history. Complete auscultation of the heart and lung sounds, as well as assessment for heart failure indicators such as jugular venous distention, Kussmaul sign, hepatojugular reflex, ascites, and peripheral edema, should be performed in these patients *(9)*.

Evaluation

The history and physical exam are important components of an examination for a patient who appears with signs and symptoms of ischemic heart disease. Vital signs (respiratory rate, blood pressure, temperature, and heart rate), a review of the patient's prescription list, and an electrocardiogram should all be performed. The patient should be evaluated for any underlying or concomitant valvular heart disease or heart failure throughout their examination*(4)*.

As part of their initial evaluation, a healthcare professional should investigate thyroid function tests, pulmonary function testing, standard blood work, including cardiac enzymes, a chest X-ray, and echocardiography. If the initial assessment and evaluation are completed urgently, intravenous access should be acquired, and the patient should be given aspirin (162 to 325 mg) and nitrates if no contraindications present. If accessible, patients should be placed on a heart monitor and pulse oximetry should be used to determine whether they require supplemental oxygen *(9)*.

Management

CTO revascularization has not been found to benefit all-cause mortality, myocardial infarction, stroke, or repeat revascularization rates; nevertheless, it has been shown to considerably enhance patients' quality of life and lessen angina symptoms *(10)*.

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patients' quality of life and lessen angina symptoms. A J-CTO score predicts the likelihood of crossing the CTO lesion within 30 minutes and is comprised of five independent factors: blunt stump appearance of the proximal cap of the occlusion, occlusion length greater than or equal to 20 mm, calcification detected within the CTO segment, the presence of a greater than 45-degree bend within the CTO segment, and prior failed PCI attempt of the CTO lesion. Each of these independent factors is worth one point in the J-CTO score; zero is considered easy, one is considered intermediate, two is considered difficult, and three is considered extremely difficult, with the probability of crossing within 30 minutes found to be 88%, 67%, 42%, and 10%, respectively ***(11)***.

The Prospective Global Registry for the Study of Chronic Total Occlusion Intervention (PROGRESS-CTO) score is another extensively used indicator to predict the technical success of CTO PCI. This predictor evaluates the CTO lesion using four independent factors: CTO lesion proximal cap ambiguity, moderate/severe tortuosity of the CTO vascular, Circumflex artery CTO, and the absence of interventional collaterals. Each of these variables is worth one point and is associated with technical achievement. A PROGRESS-CTO score of 0 correlates with 91% technical success, a score of 1 with 74%, a score of 2 with 57%, and a score of 3 with less than 4.3% ***(12)***.

Technique and technology advancements have improved procedural success and outcomes in chronic total occlusion (CTO) percutaneous intervention (PCI) ***(13)***. These difficult situations are exacerbated by the presence of coronary arterial calcification, which is common in CTOs and is an independent predictor of operative success and complications ***(14,15)***. It is possible to detect, measure, and go beyond the procedural barriers brought on by calcium in CTOs by using certain methods and tools ***(16)***.

Coronary artery calcification can have unfavorable consequences, such as decreased balloon and stent deliverability and insufficient stent expansion, resulting in less than ideal PCI outcomes. Over the past three decades, specialized devices known as plaque-modifying devices (PMDs) have been created to increase lesion compliance, change calcium, and eventually improve acute and long-term results. Examples of these devices include specialty balloons, atherectomy, and intravascular lithotripsy. More than half of CTOs had substantial calcification (17), which makes using PMDs especially tempting in this situation. Surprisingly few research have addressed the use of PMD in CTO PCI, though ***(18,19)***.

In order to increase compliance before stent insertion, the intravascular lithotripsy balloon (Shockwave Medical) uses sonic pressure waves to selectively fracture calcium deep into the artery wall ***(20)***. Although it has been shown to be safe and effective in non-occlusive calcific disease, its use during CTO PCI both intraplaque and extra-plaque after CTO crossing for in-stent occlusion, to help connect the antegrade and retrograde SIS during retrograde dissection re-

entry, and during modification procedures has only been documented in one case series and multiple case reports ***(21-23)***.

IVUS is helpful in developing CTOs at various points in the PCI process. When the proximal cap's position and degree of calcification are unclear based on angiography, this method might be utilized to clarify things. IVUS can be used to evaluate the morphology and distribution of calcium after an obstruction has been crossed, identify the best method of calcium modification, and then verify that the modification is sufficient before stent placement. Finally, it can be employed for stent optimization and stent expansion measurement. Because of the displacement of calcific plaque inside the arterial structure after dissection and re-entry with extra-plaque stenting, eccentric stent expansion is prevalent. In these circumstances, a pragmatic approach to what constitutes an acceptable stent outcome should be taken, as excessive post-dilation has the potential to cause perforation. As in non-CTO PCI, the most important predictor of long-term stent patency is absolute stent expansion, measured as minimal stent area ***(24)***.

Prognosis

In addition to generating symptoms, CTOs have been linked to a worse overall prognosis, greater rates of death, and non-fatal adverse cardiovascular events in numerous populations. Patients with CTOs are typically older, have more comorbidities, and have severe impairment in left ventricular function. Furthermore, individuals with non-revascularized CTOs have higher mortality and a higher risk of significant adverse cardiovascular events than patients with totally revascularized multivessel coronary artery disease ***(25)***.

Complications

When compared to non-CTO PCIs, percutaneous coronary intervention (PCI) of a CTO lesion needs greater fluoroscopy time, more contrast volume, and has a worse success rate. CTO PCIs also have a higher rate of significant complications than non-CTO PCIs, including myocardial infarction, stroke, vascular perforation, and death. Poorly managed bleeding, hematoma, acute thrombosis, distal embolization, retroperitoneal hemorrhage, dissection of the access artery, arteriovenous fistula, and pseudoaneurysm are all common vascular access site problems during CTO PCI. VV tachyarrhythmias, bradycardia, allergic responses, atheroembolism, and contrast nephropathy are all potential consequences ***(9)***.

Data analysis of the National Cardiovascular Data Registry-Cath PCI Registry in the United States revealed a higher in-hospital major adverse cardiovascular event frequency (1.6 versus 0.8 percent; p0.001), including mortality (0.4% versus 0.3%; p0.001), stroke (0.1% versus 0.1%; p = 0.045), tamponade (0.3% versus 0.1%; p0.001), MI (2.7% versus 1.9%; p0.001), and urgent CABG surgery in this registry, CTO PCIs also had a reduced procedural success rate (59% vs. 96%, p 0.001) ***(26)***.

Another multicenter registry (OPEN-CTO) of 1,000 consecutive patients undergoing CTO PCI from 12 CTO-PCI sites investigated success rates, complication rates, and health status benefits at one month. CTO PCIs had an 86% success rate, with 0.9% in-hospital mortality and 1.3% 1-month mortality. 4.8% of the patients had coronary perforations that needed to be treated. Furthermore, there were 7% of significant adverse cardiovascular events, 2.6% of myocardial infarctions, 0.7% of acute renal injury, and 0% of strokes ***(10)***.

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