

Complications in percutaneous treatment of chronic total occlusions: a systematic review

Complicações no tratamento percutâneo de oclusões crônicas: uma revisão sistemática

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ABSTRACT – Background: Chronic total occlusion is the subtype of lesions with the lowest procedural success rates, as well as the most common cause of incomplete revascularization and coronary artery bypass grafting. Their recanalization requires advanced techniques, dedicated materials, skilled operators and, usually, double arterial access, which makes the procedure more complex, increasing the chance of complications. Our goal is to characterize the most frequent complications in percutaneous treatment of chronic total occlusions in contemporary practice. **Methods:** We searched the PubMed/MEDLINE databases using the keywords “coronary chronic total occlusion”, “complications” and “angioplasty”. We followed the PRISMA recommendations. **Results:** Of a total of 430 references initially reviewed, 6 met the inclusion and exclusion criteria of the analysis, and accounted for the final sample. The procedural success rate was high, between 76% and 96%. The most commonly reported complications were periprocedural myocardial injury (8.6%), vascular access-related complications (2.5%), and cardiac tamponade secondary to coronary perforations (1.3%). **Conclusion:** Percutaneous treatment of chronic total occlusions creates a challenging scenario, with a high potential for complications. Patient selection must be focused on the anticipated benefits, and operators must be properly trained and capable of successfully conducting the procedure, recognizing and preventing potential procedural adverse events, and managing them when needed.

Keywords: Coronary occlusion; Coronary occlusion/complications; Angioplasty

RESUMO – Introdução: A oclusão crônica representa o subtipo de lesão com as menores taxas de sucesso de procedimento, bem como a causa mais comum de revascularização incompleta e cirurgia de revascularização miocárdica. Sua recanalização exige técnicas avançadas, materiais dedicados, operador experiente e, em geral, duplo acesso arterial, o que torna o procedimento mais complexo, aumentando a possibilidade de complicações. Objetivamos caracterizar as complicações mais frequentes no tratamento percutâneo de oclusões crônicas na prática contemporânea. **Métodos:** Realizou-se uma pesquisa nas bases de dados PubMed/MEDLINE, utilizando como ferramenta de busca as palavras-chave “oclusão coronária”, “complicações” e “angioplastia”. Foram seguidas as recomendações PRISMA. **Resultados:** De um total de 430 referências inicialmente analisadas, 6 preencheram adequadamente os critérios de inclusão e exclusão da análise, consistindo na amostra final. A taxa de sucesso do procedimento foi elevada, entre 76% e 96%. As complicações mais frequentemente reportadas foram injúria miocárdica periprocedimento (8,6%), complicações relacionadas ao acesso vascular (2,5%) e tamponamento cardíaco secundário a perfurações coronarianas (1,3%). **Conclusão:** O tratamento percutâneo de oclusões crônicas perfaz um cenário desafiador e com alto potencial de complicações. A seleção de pacientes deve ser focada nos benefícios antecipados, dispondo de operadores treinados, capazes de efetivar o procedimento com êxito, e de reconhecer, evitar e tratar as intercorrências, caso elas ocorram.

Descritores: Oclusão coronária; Oclusão coronária/complicações; Angioplastia

INTRODUCTION

Percutaneous coronary intervention (PCI) in chronic total occlusions (CTO) has evolved rapidly in recent years. With improved devices and techniques, high success

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rates can be achieved, even though overall success rates are still low.¹ CTO are diagnosed in approximately 20% of patients with coronary artery disease (CAD) and have a detrimental effect on patients' quality of life and long-term prognosis.² Significant advances in PCI devices and recanalization techniques, as well as the experience acquired by operators have enabled the current dissemination of percutaneous management of CTO.³ In respect to its etiology, CTO after acute myocardial infarction (MI) was described in 45% of patients left untreated, 30% of patients after thrombolysis, and 5% to 10% of patients after failure of primary PCI.⁴ However, 60% of patients with CTO have no prior history of MI. This may be due to recruitment of collateral vessels, to compensate for the gradual progression to a totally occluded artery, limiting myocardial damage and leading to mild or even inexistent clinical symptoms.

PCI of CTO may be indicated in cases of angina, myocardial ischemia, left ventricular dysfunction or electrical instability, particularly when the left anterior descending artery is involved.^{5,6} Records of patients with CTO have shown that successful percutaneous revascularization is associated with better clinical outcomes, i.e., improved quality of life, potentially improved myocardial electrical stability, lesser need for coronary artery bypass graft (CABG) surgery, better tolerance to future coronary events, improved left ventricular function and, in the context of complete coronary revascularization, potentially prolonged survival.⁷

The current technical success of revascularization for treating CTO is close to 90% in excellence centers.⁸ Despite the acceptable complication rates, their occurrence and the consequent failure of the procedure are associated with high morbidity and mortality rates.⁹

In this systematic review, our goal was to characterize the most frequent complications during CTO PCI, as well as their prevalence and implications for patients.

METHODS

Search strategy and eligibility criteria

We searched the PubMed/MEDLINE® databases using the keywords “coronary chronic total occlusion”, “complications” and “angioplasty”. Studies in humans, aged over 18 years, published in English, between 2014 and 2017, with access to the full text, were initially included if reporting any of the complications of CTO PCI.

Review papers, letters to the editor, and studies in which procedural complications could not be accurately assessed were excluded. We only reviewed articles that met the reference quality criteria Qualis 1, Medicine III (<http://qualis.capes.gov.br>). After analyzing the electronic databases, we performed a manual search for pertinent articles. As a protocol, we followed the recommendations provided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Data extraction

The data from studies were extracted by two authors, and controversies were reviewed by both; in case of discordance, a third reviewer was used to ensure consensus. Some data, such as authors, year of publication, and country of origin were reviewed for identification and exclusion of duplicate publications from the same cohort. The data extracted included the total number of patients and lesions, age, sex, history of prior CABG, target vessel, angiographic success, and rate of complications.

RESULTS

The process for selection of articles is described in figure 1. Of a total of 430 references initially reviewed, 6 met the inclusion and exclusion criteria of the analysis, and accounted for the final sample.

Table 1 describes the studies selected for this review, including the authors, country of origin, number of procedures, main objectives of each study, and main characteristics of the study.

In a multicenter, US registry of 250 patients, including 40.1% with diabetes mellitus, with a mean stent length of 51.7±27.2mm, procedural success rates were high (96,4%).¹⁰ One-year mortality was 1.9%, target-vessel revascularization 6.3%; and stent thrombosis 1.4%.

A retrospective analysis of 325 CTO PCI procedures assessed the clinical impact of periprocedural myocardial injury (PMI) in this context.¹¹ With technical and procedural

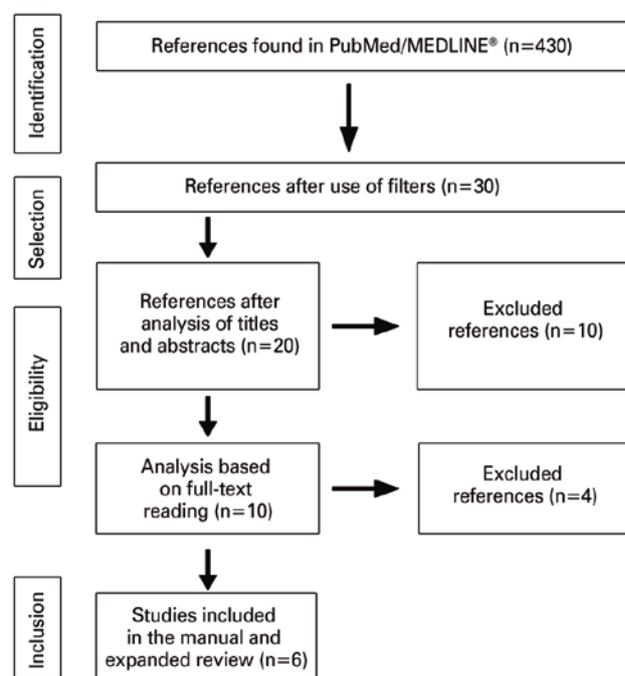


Figure 1. Selection of studies for inclusion in the analysis.

Table 1. Characteristics of the studies included.

Author	Country	Procedures (n)	Objectives	Study characteristics
Kandzari et al. ¹⁰	United States	250	Evaluation of in-hospital clinical outcomes and 1-year follow-up	Multicenter, North-American registry investigating the late efficacy and safety of CTO PCI with new-generation drug eluting stents
Lo et al. ¹¹	United States	325	Incidence, correlates and clinical implications of PMI during CTO PCI	Single center study assessing the impact of PMI in CTO management
Galassi et al. ¹²	Europe	1,582	Incidence of MACE in retrograde CTO PCI	European experience (44 sites) with retrograde CTO revascularization
Dautov et al. ¹³	Canada	470	MACE or vessel reocclusion 1 year after successful CTO PCI	Comparison of CTO PCI in patients with vs. no previous CABG
Maeremans et al. ¹⁴	Europe	1,253	Technical aspects, outcomes and in-hospital complications of CTO PCI using the hybrid algorithm	European multicenter registry reporting the outcomes achieved with adoption of the hybrid algorithm for CTO management
Tsai et al. ¹⁵	United States	2,394	Clinical and angiographic characterization and late outcomes of patients undergoing elective CTO PCI	Analysis of the VA CART program, addressing 79 veterans hospitals in a 6-year period

PCI: percutaneous coronary intervention; CTO: chronic total occlusion; PMI: periprocedural myocardial injury; MACE: major adverse cardiac events.

success rates of 77.8% and 76.6%, respectively, PMI occurred in 28 patients (8.6%), 7 of which had clinical manifestations. In 2.3-year follow-up, PMI was associated with a higher risk for major adverse cardiac events (relative risk: 2.25; $p=0.006$), even when silent.

Data from the ERCTO (European Registry of CTOs), comprising 1,395 patients and 1,582 lesions, reported the outcomes of retrograde procedures with a mean follow-up time of 24.7 ± 15.0 months.¹² Procedural failure was linked with increased risk of death (0.6% vs. 4.3%; $p<0.001$), MI (2.3% vs. 5.4%; $p=0.001$) and repeat revascularization (8.6% vs. 23.6%; $p<0.001$). Female gender, prior PCI, left ventricular dysfunction, J-CTO score, and technical failure were independent predictors of late morbidity and mortality.

The hybrid CTO PCI program of the Quebec Heart and Lung Institute published similar success rates in treating patients with or without prior CABG, emphasizing the use of venous grafts as a safe alternative for the retrograde approach.¹³ The in-hospital complications described included mortality of 0.6%, cardiac tamponade 1.1%, emergency surgery 0.2%, major bleeding 0.9%, and severe vascular complications 0.2%.

In the RECHARGE (REgistry of Crossboss and Hybrid procedures in FrAnce, the NetherlAnds, BelGIum and UnitEd Kingdom) registry, which reports the outcomes after adoption of the hybrid treatment algorithm, the success rate was 86%, with 2.6% severe in-hospital complications.¹⁴ Cardiac tamponade occurred in 1.3% of cases, retroperitoneal bleeding in 0.2%, major access-related bleeding in 0.5%, severe vascular complications in 2.5%, and acute renal failure in 0.2%.

In a review of the VA CART (Veterans Affairs Clinical Assessment Reporting and Tracking) program, 79.7% of procedures were reported as successful.¹⁵ There were 18 (0.75%) coronary perforations, only one of which leading to cardiac tamponade (0.04%). Coronary dissection occurred in 0.79%, stroke in 0.04%, and PMI in 0.13%.

DISCUSSION

In the last 35 years, there have been numerous technical and pharmacological advances in the field of PCI. However, treating CTO is still a great challenge and a frequent reason for patients undergoing CABG. At least one CTO is reported on 18 to 20.4% of diagnostic coronary angiograms in patients with coronary artery disease.¹⁶ The development of new dedicated devices or strategies for CTO PCI, such as double arterial access, intravascular imaging, atherectomy, microcatheters, penetration catheters, new balloons (CrossBoss/Stingray), dedicated guidewires, led to considerably higher success rates and decreased complications.¹⁷ However infrequent they may be, a better understanding of the mechanisms involved in the occurrence of complications in CTO interventions can help limit these events.

Among the potential events, coronary perforation has considerably high morbidity and mortality. Its prevalence is currently estimated at around 2.9%, based on a meta-analysis of 65 studies with 18,061 patients enrolled.¹⁸ In recent data reported by the British Cardiovascular Intervention Society (BCIS), looking at an expressive 26,807 CTO PCI cases, the rate of coronary perforation was 1.4%.¹⁹ Of these, 16.6% progressed to cardiac tamponade and 3.4% required emergency heart surgery. The advent of covered stents and embolization techniques (coils, fat, thrombi) can explain the relatively low need for surgical procedures. However, coronary perforation led to a 6-fold increase in the 30-day mortality risk, and the main predictors were female gender, advanced age, previous PCI, circumflex artery involvement, and adoption of advanced management techniques.

Vascular complications occur in approximately 0.6% of patients undergoing CTO PCI, and the radial approach is associated with a lower risk of bleeding and adverse events compared with the femoral approach.²⁰ The use of the radial approach in complex interventions is growing, despite its

disadvantages, like the lesser level of support and possibility of using larger caliber devices. In a recent analysis of the PROGRESS CTO (Prospective Global Registry for the Study of Chronic Total Occlusion Intervention), comprising 3,790 procedures, the radial approach showed similar technical success, procedural success and adverse event rates when compared to the femoral approach, with less risk of major bleeding (0.55% vs. 1.94%; $p=0.013$).²¹

Coronary dissection and occlusion of lateral branches are common complications that can be avoided with careful monitoring of the guide catheter, wires and other devices. Entrapment or loss of materials are rare events, however they requires retrieval and/or crushing against the coronary wall. All patients undergoing CTO PCI must be evaluated for risk of contrast-induced nephropathy and receive hydration as tolerated. CTO PCI sometimes entails a significant exposure of the patient to radiation and, therefore, careful monitoring for radiation-induced skin lesions is required in patients receiving >4-5 Gy (air kerma).²²

PMI in CTO PCI is frequent, with a higher prevalence in the retrograde approach, and associated with poorer subsequent clinical outcomes.¹¹ In-stent restenosis, stent thrombosis or development of aneurysms are also reported as long-term complications. After a successful procedure, collateral circulation declines rapidly, reducing myocardial tolerance to ischemia, and placing the patient at risk of future ischemic events in case of sudden reocclusion of the vessel. Therefore, the use of antiplatelet therapy with prolonged administration of acetylsalicylic acid and clopidogrel after recanalization and stenting is advocated.²³

There is a joint effort underway to encourage the development of new techniques and devices for the treatment of chronically occluded coronary arteries, supported by recent studies, as well as guidelines and hybrid treatment protocols (algorithms). Recent analyses show that CTO PCI currently has higher success rates, and low and decreasing complication rates, suggesting a favorable risk/benefit ratio and supporting its growing use in a group of selected patients.

CONCLUSION

Percutaneous treatment of chronic total occlusions creates a challenging scenario, with a high potential for complications. Currently, procedural success rates are close to 90% in selected cases, with benefits outweighing risks. Therefore, patient selection must focus on the anticipated benefits in terms of quality of life and long-term outcomes, not on the anatomical complexity of lesions alone. We must have well-trained operators, capable of successfully conducting the procedure, in addition to recognizing and preventing procedural adverse events, and managing them whenever required.

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CONFLICTS OF INTEREST

The authors declare there are no conflicts of interest.

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