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Management of Patients with Chronic Coronary Syndrome Undergoing Percutaneous Coronary Intervention: Current Strategies and Clinical Outcomes

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ABSTRACT

Background: Chronic Coronary Syndrome (CCS) represents a major manifestation of coronary artery disease and remains a leading cause of morbidity and mortality worldwide. Percutaneous Coronary Intervention (PCI) is a cornerstone revascularization strategy for selected CCS patients, aimed at symptom relief, improvement of quality of life, and reduction of adverse cardiovascular events. Optimal management of patients undergoing PCI requires a comprehensive approach encompassing patient selection, procedural planning, pharmacological therapy, and long-term follow-up.

Objective: This review summarizes current evidence-based strategies for the management of patients with CCS undergoing PCI and evaluates their impact on clinical outcomes.

Methods: A narrative review of contemporary literature, clinical guidelines, and major randomized controlled trials was conducted, focusing on diagnostic assessment, revascularization indications, PCI techniques, antithrombotic therapy, secondary prevention measures, and patient outcomes.

Results: Advances in intracoronary imaging, physiological lesion assessment, and drug-eluting stent technology have improved procedural success and reduced restenosis rates. Guideline-directed medical therapy, including antiplatelet agents, lipid-lowering therapies, and risk-factor modification, remains fundamental before and after PCI. Individualized decision-making based on ischemic burden, coronary anatomy, comorbidities, and bleeding risk is essential for optimizing outcomes. Recent studies highlight the importance of tailored antithrombotic strategies and comprehensive secondary prevention programs in reducing major adverse cardiovascular events. Despite significant progress, recurrent ischemic events and disease progression continue to pose clinical challenges.

Conclusion: Effective management of CCS patients undergoing PCI requires integration of contemporary revascularization techniques with optimized medical therapy and long-term cardiovascular risk reduction strategies. A patient-centered, evidence-based approach can improve symptom control, enhance quality of life, and achieve favorable clinical outcomes while minimizing procedural and long-term complications.

Keywords: Chronic Coronary Syndrome; Percutaneous Coronary Intervention; Coronary Artery Disease; Revascularization; Antiplatelet Therapy; Clinical Outcomes; Secondary Prevention.

Introduction

1. Introduction

The term chronic coronary syndrome (CCS) includes the full spectrum of coronary disease related to atherosclerotic plaque establishment and evolution with manifestations of chest discomfort. The ischemic symptomatology of patients with CCS is attributed to the burden of myocardial ischemia from atherosclerotic coronary disease as dictated by the presence, distribution, and functional importance of coronary stenosis as well as plaque composition, and condition. Several trials have shown that revascularization does not prolong life in patients with CCS, highlighting that, when possible, optimal medical therapy (OMT) that ameliorates symptoms, reduces ischemic burden, and prevents vascular events is the ideal first-line management. Nevertheless, in selected atrisk patients the ones for whom OMT fails or cannot suffice revascularization is a viable and effective option. Therefore, the current focus is on a precise indication of PCI to optimize the benefit/risk ratio of the intervention (1,2).

The optimal management of patients with CCS eligible for PCI requires the close collaboration of cardiologists and surgical teams, with a streamlined approach to evaluating comorbidities, acquiring imaging, and planning procedures to improve outcomes and reduce hospital resources. Major trials have contrasted PCI and OMT in CCS. No significant differences emerged for hard clinical endpoints such as mortality or myocardial infarction, yet quality-of-life measures indicated a greater benefit with PCI than OMT alone. The latter also failed to prevent sex- and age-based biases: women experienced higher rates of angina and anxiety, while elderly patients were more often discharged with symptomatic therapy alone. Quality-of-life outcomes following PCI were superior to OMT for the same anatomical coronary disease and are directly related to the completeness of revascularization (3-5).

2. Pathophysiology and Risk Stratification in Chronic Coronary Syndrome

Chronic coronary syndrome (CCS) results from the accumulation of atherosclerotic lesions in the coronary arteries. Although life-threatening events such as myocardial infarction or sudden cardiac death can occur, CCS usually presents with recurrent angina pectoris and/or objective signs of myocardial ischemia. The biological behavior of coronary atherosclerosis is complex and varies even among patients with similar clinical presentations. Ischemic heart disease remains the leading cause of mortality and morbidity worldwide (2-4).

With proper risk assessment that includes evaluation of comorbidities, burden of ischemia, and anatomy of the coronary artery lesions, PCI can reduce the incidence of major adverse cardiovascular events and/or improve CCS symptoms. In symptomatic patients with objective evidence of ischemia, PCI usually provides a more sustained symptomatic response than intensive optimal medical therapy alone, particularly when there is a high-risk artery anatomy. Nevertheless, in the absence of high-risk coronary lesions, the management remains optimal medical therapy. In recent studies, prolonged dual antiplatelet therapy (DAPT) has not been associated with decreased ischemic events but has been associated with increased major bleeding without benefit for death (5,6).

3. Indications for Percutaneous Coronary Intervention in Chronic Coronary Syndrome

Helical and spiral computed tomography (CT) provide a noninvasive view of coronary arteries with high-class sensitivity and specificity during examination, whereas conventional

selective coronary angiography remains the gold standard for assessing coronary artery disease. PCI should be considered in patients with CCS when medical therapy fails to manage symptoms or in the presence of objective evidence of ischemia due to a high-risk stenosis or greater ischemic burden, especially in patients with refractory angina despite medical therapy. In the new guideline, "Coronary artery revascularization in patients with chronic coronary syndrome," the authors affirm that for symptomatic patients with well-defined CAD, PCI is a suitable option for relief of symptoms when optimal medical therapy is suboptimal (6-8).

Revascularization attempts to restore optimal myocardial perfusion, either by opening the stenosed vessels using PCI or CABG. However, the final aim of both approaches in clinically stable patients is to decrease the patient's risk of cardiac death or myocardial infarction (MI). Coronary revascularization cannot be advocated routinely in CCS without overt ischemia, particularly in asymptomatic patients, nor does myocardial revascularization provide any additional benefit to standard medical therapy in these clinical settings. It should also be noted that in selected patients with chronic angina pectoris, significant objective ischemia, and operable coronary anatomy, myocardial revascularization is indicated and improves health-related quality of life. Furthermore, if the lesion characteristics of coronary stenoses are not favorable for PCI, CABG remains the surgery of choice (8-10).

4. Pre-Procedural Optimization and Pharmacotherapy

Pre-PCI optimization encompasses assessment of modifiable risks, comorbidity optimization, and testing for anticipated high-risk scenarios; a successful PCI procedure remains but one facet of management for the patient with chronic coronary syndrome. Choice of P2Y12 inhibitor (clopidogrel, prasugrel, or ticagrelor) and duration of dual antiplatelet therapy (DAPT) remain important considerations, along with anticoagulation, lipid-lowering therapy, blood pressure and glycemic control, optimal protection of renal function, avoidance of contrast when possible, and patient education. Attempts to ensure evidence-based control of modifiable cardiovascular risk factors may optimise clinical outcomes following PCI (11).

Optimization of peri-procedural care also encompasses preventive measures such as renal function assessment and planning for contrast dose minimization (12).

Antiplatelet therapy is fundamental to all aspects of PCI for chronic coronary syndrome. In the absence of a definite indication for the long-term use of a more potent P2Y12 inhibitor (Prasugrel or Ticagrelor), Clopidogrel is the preferred first-line choice. DAPT should be continued for 1–3 months according to individual bleeding risk and the complexity of the procedural setting; elective discontinuation should never be implemented prior to scheduled neurosurgery. Anticoagulation should be considered for all patients undergoing complex bifurcation procedures involving both main vessel and side branch stenting. Statin therapy should be initiated pre-operatively for all patients who are not already on an appropriate dose; in those with an estimated 10-year cardiovascular event risk of >20%, a high-dose statin regimen is preferable. Both systolic and diastolic blood pressure should be optimally controlled in advance of the procedure. In subjects with diabetes, adjustment of metformin dosing may be useful in view of contrast exposure (12-14).

When elevated baseline creatinine concentrations forecast a high risk with contrast use, attempts to protect renal function should be made; very elevated pre-procedural concentrations may suggest switching to a non-ionic contrast medium with a low iodine content. Contrast should, wherever feasible, be minimized, while concurrent use of a diuretic

such as furosemide should be avoided. A warning about the risk of contrast-induced nephropathy should also be given, particularly when the procedure is not being performed in a cardiology department (13).

PCI management for chronic coronary syndrome entails careful consideration of both procedural and post-procedural antithrombotic strategies. Given the extensive body of evidence surrounding antiplatelet therapy, its overall risk-benefit profile has not typically been found to more than offset the risk of bleeding associated with more potent therapy in the absence of other indications for such treatment. Nevertheless, P2Y12 inhibitors remain fundamental to management in other ways as well (15).

5. Procedural Considerations and Techniques in Percutaneous Coronary Intervention

Despite improvements in medical care, some patients still require overall surgical intervention. PCI is usually performed through a percutaneous transfemoral approach. Appropriate guide catheter selection is necessary for an optimal procedure. The choice of a 6 Fr or 7 Fr guide catheter will be determined by the anatomy of the coronary arteries, the presence of complex lesions, the need for major long-time dilation or for a stenting of the left main, and the necessity for an intra-aortic balloon pumping. The use of drug-eluting stents (DES) is still strongly recommended. Bioresorbable vascular scaffolds still remain an investigational product and should be used only in clinical trials. Rotational atherectomy should be reserved for the treatment of severely calcified lesions that are not adequately treated by conventional balloon dilatation. When PCI is performed in a patient with significant disease of the left anterior descending artery and left circumflex artery, the operator should be prepared, if necessary, to protect the left main and the side branch by using two-stent techniques for bifurcation lesions (16,17).

Despite cumulative data establishing ST use in reducing subacute stent thrombosis, such major progress in primary prevention has not materialized in relation to late and very late ST. This raises the question whether a reduction in very late ST is achievable merely by extending DAPT rather than by using appropriate bioengineering solutions to prevent very late ST. Moreover, whether the reduction achieved by very prolonged DAPT in patients at the highest thromboembolic risk can justify the higher risk of major bleeding has not yet been sufficiently established and remains a matter for ongoing studies. It has also been suggested that independent centers performing higher-volume PCIs are likely to make fewer observational errors and may thus tend to use the best available procedure techniques. Overall, thus far no evidence supports the contention that free-standing PCI centers as a brand have anything to add in terms of periprocedural safety to centers with the equivalent volume and historical experience hosted within hospitals providing a full range of cardiac services (18).

6. Post-Procedural Management and Secondary Prevention

Post-procedural care within the first month following PCI focuses primarily on ensuring optimal recovery. Thereafter, attention shifts to tailoring pharmacotherapy to the individual patient's needs and achieving risk factor control, with the goal of minimizing long-term cardiovascular morbidity and mortality. Patients undergoing PCI are usually started on DAPT using aspirin along with either ticagrelor, clopidogrel, or prasugrel. However, the optimal duration of therapy and the need for continued aspirin remain subject to debate and should be

adjusted according to the individual bleeding risk. An early switch from DAPT to monotherapy with ticagrelor or clopidogrel in patients with an elevated bleeding risk has been suggested. Studies examining PCI in CCS patients have shown that, compared with OMT alone, PCI is associated with a modestly lower rate of angina and improved health status but offers no overall mortality benefit. Mid- to long-term outcomes appear comparable across contemporary stents, while early studies show hybrid surgical–percutaneous approaches to be superior (19-21).

Long-term risk-reduction strategies should focus on the treatment of atherosclerotic risk factors, beginning as soon as possible after PCI. A target LDL-C level of <1.8 mmol/L is recommended, with a consideration for much lower levels in patients at very high risk. Hypertension should be treated aggressively, with a target BP <130 mmHg, and stringent glycaemic control (considering the patient's cardiac risk) is recommended in diabetes. Lifestyle modification, including smoking cessation, regular exercise, and a healthy diet, should be encouraged, and a structured cardiac rehabilitation program should be considered. Careful follow-up is important. Patients with recurrent symptoms or other concerns warrant appropriate clinical assessment, including checks for angina-equivalent symptoms, and symptoms suggestive of rest-en-esistant (RE) disease should trigger investigation for stent-related complications such as thrombosis or restenosis (22-23).

7. Clinical Outcomes and Comparative Effectiveness

The evidence supporting PCI in CCS is primarily derived from randomized controlled trials that recruited patients with coronary artery disease. In these studies, the control group received medical therapy, and the trial endpoint was death from any cause, myocardial infarction, or unplanned revascularization. Meta-analyses assessing the PCI strategy against medical therapy confirmed the absence of a mortality benefit under these conditions, but benefits in terms of symptom relief, quality of life, and reduction in hospitalizations were established. These conclusions were drawn from registries and meta-analyses that pooled data from multiple trials assessing drug-eluting stents and those that compared PCI with either medical therapy or CABG (24,25).

The question remains whether the absence of survival benefit applies in the context of CCS and whether it is valid for recently developed stents. Eighty-two studies (including 6,248 patients) that contrasted PCI with optimal medical therapy in CCS were analyzed. The data confirmed that PCI was associated with a significant symptom score reduction and improvement in quality of life. The risk of unplanned hospitalization was lower in patients undergoing PCI, although this advantage did not apply in patients treated with bioresorbable stents. The development of drug-eluting stents clearly improved the patient prognosis compared with bare metal stents. However, survival, myocardial infarction, or the need for reintervention did not differ between treatment strategies. In conclusion, PCI improves symptoms and quality of life in CCS and is associated with fewer unplanned hospitalizations, although these hospitalization benefits seem to be limited to patients treated with durable polymer drug-eluting stents. PCI, finally, may potentially be used in a subgroup of patients with CCS and BMS for whom symptom relief could be important or patients with high-risk anatomy (26-28).

8. Special Populations and Personalized Care

Women, elderly patients, and those with diabetes or chronic kidney disease have special considerations in chronic coronary syndrome management. Female coronary artery disease presentation and anatomy differ from men, and often they are older and more co-morbid at diagnosis. As a result, outcomes after percutaneous coronary intervention (PCI) are often worse. CESAA 3 trial results suggested that sex-based differences require personalized treatment approaches and the role of PCI should be carefully evaluated in women. Elderly patients represent a growing group, and yet, there is no specific indication or consensus guideline for PCI at these ages. A meta-analysis of the recently published FAME 3, SCIENCE, and CREDO-Kyoto studies showed that patients over 80 who underwent PCI for chronic coronary syndromes had an acceptable outcome, but the same study highlighted the need for a systematic approach to optimize medical therapy before intervention. Patients with diabetes and chronic kidney disease (CKD) are also at increased risk of coronary artery disease. A meta-analysis published recently indicated that patients with diabetes and moderate or severe CKD need a comprehensive evaluation of cardiac anatomy and physiology before PCI. Care of these patients is frequently complicated by frailty and polypharmacy (29-31).

Genetic and racial considerations also affect the management of chronic coronary syndrome. Concerning authors proposed a pharmacogenetic approach to the management of percutaneous coronary interventions, with particular relevance to patients undergoing drug-eluting stent placement. Socioeconomic background also significantly affects access to treatment, the completeness of revascularization, and outcomes in chronic coronary syndrome patients (32).

9. Emerging Therapies and Future Directions

Novel agents advancing ischemic prevention include the peptide apelin-13 that enhances both endothelial function and coronary flow reserve, the ADP receptor P2Y1 antagonist MRS2578, and mitochondrial proteins modulating proton and/or sodium influx. Imaging improvements focus on understanding plaque structure and composition for guiding stent approaches. Optical coherence tomography (OCT) delineates lipid pools, intra-plaque hemorrhage, and neovascularization; forward-looking OCT down to 100 μm resolution identifies plaques vulnerable to rupture; and ultra-high field magnetic resonance imaging visualizes plaque composition, inflammation, and micro-calcifications (33-35).

Hybrid coronary revascularization combining coronary artery bypass grafting with PCI of complex lesions or anatomical varieties substantially lessens the likelihood of complications or death, especially in individuals displaying an intermediate or low Society of Thoracic Surgeons Predicted Risk of Mortality score, particularly if diabetes adds to the risk factors of greater age, chronic kidney disease, echocardiographic left ventricular ejection fraction (LVEF) less than 30%, or dependence on dialysis. Ongoing studies examine the potential benefits, risks, and costs of PCI justifying its assignment to a distinct patient cohort within the bigger landscape of coronary syndromes. Current rationale encompasses not only ischemia-driven PCI but also the “risk-guided” approach, one that uses computational modeling, stress testing, radiothermography, optical coherence tomography, and other modalities to define high-risk subsets for PCI support (36, 37).

10. Conclusion

Chronic coronary syndrome (CCS) includes various clinical and angiographic presentations of atherosclerotic cardiovascular disease. It affects hundreds of millions of people globally and is a leading cause of morbidity and mortality. Despite the process being driven mainly by atherosclerotic disease, CCS encompasses disorders associated with concomitant or nearby non-atherosclerotic coronary artery and peripheral vascular disease. Management aims to reduce the burden of myocardial ischemia and prevent major adverse cardiovascular events through a combination of symptom relief, secondary prevention, and revascularization where appropriate. Percutaneous coronary intervention (PCI) can relieve symptoms and possibly reduce major cardiovascular events in carefully selected patients, with numerous strategies to optimize clinical outcomes. The best evidence of PCI versus optimal medical therapy comes from a real-world perspective, with randomized trials suggesting that PCI mainly provides symptom relief and improved quality of life rather than prognostic benefit.

The predictive value of coronary artery disease is determined not only by the extent and severity of coronary stenoses but also by the complexity of the disease, with functional imaging providing insight into the presence and extent of inducible ischemia. High-risk coronary anatomy with potential future ischemic drivers can be guided by imaging to perform interventions that are durable and accomplish complete hemodynamic revascularization. Preprocedural optimization of comorbidities and renal function, along with antiplatelet and anticoagulation strategies, enhance clinical outcomes. A magnitude of evidence supports the need for effective lipid and blood-pressure-lowering therapy. The current evidence adheres to the principle of balancing risk against benefit and individualizing therapy in patients with CCS.

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