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Coronary ischemia and percutaneous intervention

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Abstract

The interventional treatment of ischemia is a complex issue grounded on an understanding of basic pathophysiology, but translated and implemented in practice by extensive clinical trial data representing patients with a spectrum of ischemia-causing clinical syndromes and anatomical variations of coronary artery disease (CAD). Percutaneous coronary intervention (PCI) has evolved to treat ischemia within this matrix of clinical and anatomical subsets using a wide array of techniques. Initial techniques using balloon angioplasty were promising, but demonstrated significant rates of restenosis due to negative arterial remodeling. The advent of stent technology prevented arterial recoil and provided a viable treatment for flow-limiting coronary dissections, thereby facilitating improved long-term patency of coronary vessels without the need for repeat revascularization. In-stent restenosis has been successfully addressed with drug elution, but late stent thrombosis has emerged as a complex issue involving dual antiplatelet therapy, patient compliance, and reexamination of the delicate balance between reducing restenosis and promoting endothelial proliferation. Finally, complex coronary lesions associated with heavy calcification or extensive plaque/thrombus burden that introduce unique challenges in obtaining ideal angiographic results have led to the development of new debulking devices aimed at optimizing procedural outcomes. This review will describe a variety of percutaneous coronary interventional techniques and technologies that are employed in the invasive treatment of ischemia under the guidance of clinical guidelines and evidence-based medicine.

Keywords: Coronary ischemia; IVUS; Vascular response; Pathophysiology

1. Introduction

Although significant advances in medical therapy aimed at alleviating the detrimental pathophysiologic response to acute coronary syndrome (ACS) have been made in the last decade, the advent of percutaneous therapies in managing ACS has truly revolutionized the field of cardiology. Through the use of multiple techniques and technologies developed through extensive clinical research, PCI has evolved into the mainstay of treatment for ischemic heart disease. With a large arsenal of techniques, technologies, and devices at their disposal, interventional cardiologists are regularly faced with the challenge of quickly integrating evidence from clinical trials with various patient characteristics in order to determine the ideal invasive management strategy in treating patients with ACS. This review will describe a variety of PCI techniques and technologies that are employed in the invasive treatment of ischemia under the guidance of clinical guidelines and evidence-based medicine.

2. Evidence-based guidance in coronary interventions

Extensive clinical trial experience has served as the foundation in developing clinical guidelines in the use of interventional techniques. These practice guidelines are instrumental in assisting the clinician in either making

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patient-specific decisions or deviating from recommendations when clinically indicated. A fundamental principle in the formulation of clinical guidelines is the balance between risk and benefit in performing an intervention. A high benefit-to-risk ratio leads to a strong recommendation (Class 1) for performing an intervention, while situations where risk is greater than benefit are contraindicated (Class 3). Class 2 recommendations capture the broad zone of recommendations when interventions may be considered, but with a lesser degree of certainty with regard to risk–benefit. Furthermore, the degree of certainty surrounding these recommendations is based on the strength of available evidence from published studies where a Level A degree of certainty is assigned when multiple studies using a randomized design show consistent evidence that an intervention reaches a clear benefit with an acceptable risk and Level B and C designations are assigned when the evidence is less certain to variable degrees. For example, the classification of an interventional procedure as 1A designates it as a recommended practice with benefit that exceeds the risk (Class I) and that is based on multiple randomized trials or meta-analyses representing multiple population risk subgroups (Level of Evidence: A) Currently, the American College of Cardiology/American Heart Association (ACC/AHA) designates three 1A recommendations for performing interventions in specific groups of patients with various well-defined forms of ischemia: PCI in nonelderly cardiogenic shock patients with myocardial infarction, primary PCI for myocardial infarction within 90 min of presenting to a skilled operator/institution, and use of a drug-eluting stent (DES) as an alternative to bare-metal stents (BMSs) in selected subsets of patients [1]. Furthermore, definite recommendations have been made regarding the choice of drug-eluting or BMSs in certain clinical scenarios (Table 1) [2]. Finally, while the recommended practice guidelines cover the major clinical syndromes of ischemia [i.e., silent ischemia, stable angina, unstable angina, non-ST-elevation myocardial infarction (NSTEMI), and ST-elevation myocardial infarction (STEMI)], specific recommendations exist for patients with myocardial infarction with either cardiogenic shock or in need of facilitated and rescue angioplasty.

Additional patient characterization is also performed to assist in identifying high-risk patients who may benefit greatly from PCI over medical management. For example, the TIMI risk score is commonly calculated in patients with unstable angina and NSTEMI and reflects the fact that there exists a wide spectrum of risk with patients meeting criteria for ACS [3]. To calculate the TIMI risk score, seven variables are assessed on admission and a composite score is determined. Specifically, one point is given for each of the following variables: age 65 years or older; at least three risk factors for CAD; prior coronary stenosis of 50% or more; ST-segment deviation on initial ECG; at least two anginal events in the prior 24 h; use of aspirin in prior 7 days; and elevated serum cardiac biomarkers. Mortality, recurrent infarction, or recurrent ischemia is likely in 40.9% of patients with a TIMI risk score of 6 to 7 vs. only 4.7% in those with a TIMI risk score of 0 to 1. This triaging process is important in understanding how PCI is applied to patients with ischemia with higher patient risk largely driving the degree of benefit from PCI.

Finally, the risks and benefits of PCI in the treatment of ischemia are also determined by the type of coronary lesion (s) found at the time of diagnostic angiography. The major subcategories of coronary lesions are chronic total occlusions, ostial and bifurcation lesions, saphenous vein graft (SVG) and arterial graft disease, in-stent restenosis, multivessel CAD, and left main lesions. Extensive data addresses the safety and effectiveness of PCI in regard to single native vessel lesions incorporating a wide array of disease characteristics including lesion length, calcification, eccentricity, presence of thrombus, and degree of vessel tortuosity. In addition, the various interventional technologies and devices discussed in this review have been evaluated for use in specific lesion subtypes.

3. Endothelial dysfunction in the setting of ischemia

The cellular events leading to endothelial dysfunction and subsequent myocardial ischemia involve a myriad of molecular processes initiated by the activation of the vascular endothelium by pro-inflammatory cytokines and subsequent recruitment of leukocytes to areas of inflammation mediated by selectin adhesion molecules and cellular adhesion molecules (i.e., VCAM-1, ICAM-1) [4]. The migration of these cells into the intimal layer [5,6] leads to plaque accumulation promoting endothelial dysfunction

Table 1
ACC/AHA/SCAI Class 1 guideline recommendations for DESs or BMSs[a]

Level of Evidence A	Level of Evidence B	Level of Evidence C
A DES should be considered as an alternative to a BMS in those patients for whom clinical trials indicate a favorable effectiveness/safety profile	Before implanting a DES, the interventional cardiologist should discuss with the patient the need for and duration of DAT and confirm the patient's ability to comply with the recommended therapy for DES	In patients undergoing preparation for PCI and are likely to require invasive or surgical procedures for which DAT must be interrupted during the next 12 months, consideration should be given to BMS implantation or performance of balloon angioplasty

DAT: dual-antiplatelet therapy.

[a] Adapted from Table 16 of King et al. [2, p. 282].