JACC: CARDIOVASCULAR INTERVENTIONS VOL. 11, NO. 18, 2018

PUBLISHED BY ELSEVIER

STATE-OF-THE-ART REVIEW

A Practical Approach to the Management of Complications During Percutaneous Coronary Intervention

Francesco Giannini, MD,[a,*] Luciano Candilio, MD,[a,b,*] Satoru Mitomo, MD,[a] Neil Ruparelia, MD,[a] Alaide Chieffo, MD,[a] Luca Baldetti, MD,[a] Francesco Ponticelli, MD,[a] Azeem Latib, MD,[a] Antonio Colombo, MD[a]

ABSTRACT

Percutaneous coronary intervention relieves symptoms in patients with chronic ischemic heart disease resistant to optimal medical therapy and alters the natural history of acute coronary syndromes. However, adverse procedural outcomes may occur during the intervention. Knowledge of possible complications and their timely management are essential for the practicing cardiologist and can be life-saving for the patient. In this review, the authors summarize potential complications of percutaneous coronary intervention focusing on their practical management. (J Am Coll Cardiol Intv 2018;11:1797–810) © 2018 by the American College of Cardiology Foundation.

Percutaneous coronary intervention (PCI) is currently indicated for the management of patients presenting with acute coronary syndrome and in individuals with chronic stable angina that is refractory to optimal medical therapy. Advances in devices, stent design, adjunctive technology, development of more potent and effective antiplatelet therapy, and judicious use of PCI are increasing the safety of the procedure. However, major periprocedural complications during PCI still occur. These problems can be related to the access site, intubation of the coronary artery ostia, or the intervention itself. In the current review, we describe possible complications during PCI, focusing on those occurring in the context of coronary intubation and target vessel or site intervention, including coronary perforation, abrupt vessel closure (AVC), stent deformation (and loss), wire fracture (and loss), device embolization, and rotational atherectomy burr entrapment. Management of these complications is predominantly based on operator experience and small case series with limited available guidance in the literature on account of their relative rarity. Therefore, we intend to provide recommendations relating to the practical aspects of their timely recognition and treatment.

CORONARY PERFORATION

Coronary perforation has an estimated incidence of 0.5% (1,2) and is associated with a 13-fold increase of in-hospital major adverse events and a 5-fold increase of 30-day mortality (2). It is most commonly caused by balloon or stent mismatch (oversizing of the dilatation catheter, particularly when the balloon-artery ratio is >1.2:1 or when semicompliant balloons are inflated at very high pressure) (3), but can occasionally occur with the use of an appropriately sized catheter in the context of extensive dissection or lack of vessel wall integrity, occur in the presence of arterial calcification, or be caused by inadvertent coronary wire tip migration. Other factors associated

From the [a]Unit of Cardiovascular Interventions, IRCCS San Raffaele Scientific Institute, Milan, Italy; and the [b]Cardiovascular Department, Hammersmith Hospital, Imperial College, London, United Kingdom. The authors have reported that they have no relationships relevant to the contents of this paper to disclose. *Drs. Giannini and Candilio contributed equally to this work and are joint first authors.

Manuscript received January 7, 2018; revised manuscript received May 7, 2018, accepted May 29, 2018.

ISSN 1936-8798/$36.00 https://doi.org/10.1016/j.jcin.2018.05.052

ABBREVIATIONS AND ACRONYMS

AVC = abrupt vessel closure

CABG = coronary artery bypass grafting

CTO = chronic total occlusion

GP = glycoprotein

IVUS = intravascular ultrasound

LSD = longitudinal stent deformation

MI = myocardial infarction

PCI = percutaneous coronary intervention

PTFE = polytetrafluoroethylene

with coronary perforation include the use of atherectomy devices (e.g., excimer laser or rotational atherectomy) (4), cutting balloons, intervention on a chronic total occlusion (CTO) (5), advanced age, female sex, and previous coronary artery bypass grafting (CABG) (2).

Coronary perforation has traditionally been classified into 3 types based on its severity (Ellis classification) (6). Grade III perforations may cause cardiac tamponade, rapid hemodynamic collapse, myocardial infarction, and death (1,2,7–12).

Management of coronary perforation depends on its severity (i.e., the extent of contrast medium extravasation observed on coronary angiography) and associated hemodynamic compromise, and it is based on the emergent requirement to stop coronary extravasation and ensure hemodynamic stability in the shortest possible time. **Figure 1** illustrates the potential approaches to coronary perforation during PCI and highlights the different management strategies that should be considered according to the perforation site.

The sudden onset of acute and sharp chest pain during balloon inflation or stent deployment should always raise the suspicion of coronary perforation and, in these cases, balloons should remain in the guiding catheter and at the lesion site until further angiography has been performed to confirm (or exclude) the diagnosis. Once this complication is confirmed, reversal of anticoagulation could be considered and unfractionated heparin may be neutralized with intravenous administration of protamine (recommended dose of 1 mg intravenously for each 100 units of unfractionated heparin administered) to achieve an activated clotting time of <150 s (13). However, this decision should be balanced against the potential subsequent risk of acute thrombosis of a stent that has just been deployed (14). If bivalirudin (as opposed to heparin) has been administered, infusion of fresh frozen plasma may be the only option to partially reverse anticoagulation, although the relatively short half-life of bivalirudin is advantageous here and may facilitate a more rapid hemostasis following cessation of the infusion (15).

Once coronary perforation is confirmed, the same balloon responsible for the perforation should immediately be positioned at the perforation site even before pericardiocentesis as a temporizing measure to achieve immediate hemostasis. The balloon should be inflated at the lowest possible pressure to promote hemostasis as verified by contrast injection at regular intervals: usually inflations to 2 to 4 atm for approximately 5 to 10 min are sufficient, depending on localization and extent of the perforation and on the tolerability of the patient with occlusion of the coronary vessel with a specific focus on the development of myocardial ischemia and hemodynamic instability. In case of incomplete sealing, the balloon should be placed in the correct position and inflated at higher pressure. If the perforation involves the left main artery, a perfusion balloon (e.g., Ryusei, Kaneka Medix, Osaka, Japan) or a covered stent should be considered as first-line therapy.

Once the vessel is occluded by the balloon, the patient's hemodynamic may normalize; however, aggressive treatment with intravenous fluids, atropine, vasopressors, and occasionally mechanical circulatory support may be required. The presence of coronary perforation should also encourage immediate echocardiography, and when a large pericardial effusion is associated with tamponade physiology, emergent pericardiocentesis is indicated. Aspirated blood should be immediately reinfused into a vein to promote hemodynamic stability.

While Ellis grade I perforations can occasionally resolve without intervention or can generally be treated with reversal of anticoagulation or balloon inflation at/proximal to the target vessel segment, cases of more severe perforation (Ellis grades II to III) are often associated with persistent extravasation despite prolonged balloon inflations. In these instances, other measures to be considered include the local delivery of subcutaneous fat, the use of thrombin, occlusive coils, beads, or the implantation of polytetrafluoroethylene (PTFE) stents. In most cases, percutaneous measures alone are successful; however, emergency cardiac surgery may be required and cardiac surgeons should be notified immediately. **Figures 1 and 2** summarize the approach to a patient with coronary perforation.

The development of PTFE-covered stents constitutes a major advance in the treatment of coronary perforation. These devices have significantly reduced rates of cardiac tamponade, need for emergency cardiac surgery (11,16) and mortality associated with coronary perforation (12) and are now widely available. Furthermore, current-generation covered stents have acceptable deliverability in comparison with their predecessors. In the presence of a relatively small perforation with no significant hemodynamic compromise, a single guiding catheter strategy is often sufficient and shortens treatment time. This technique consists of the rapid positioning of the covered stent immediately after deflation and retrieval of the balloon responsible for the perforation. It is important to note, however, that despite