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EDITORIAL COMMENT

Interventional Standby for CABG Surgery

The Reverse Paradigm*

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In the early days of percutaneous coronary intervention (PCI), when only balloon angioplasty was available, abrupt coronary closure or coronary dissection could only be treated by salvage coronary artery bypass grafting (CABG) surgery, which was then performed in approximately 3% of the patients (1). As stent technology improved and potent antithrombotic agents were developed, indications for emergent CABG were restricted to coronary perforation or incomplete revascularization and became increasingly rare, affecting <0.5% of patients nowadays (2-4). Consequently, cardiac surgical backup for PCI, initially a formal surgical standby, slowly evolved toward an informal arrangement with on-site cardiac surgeons, while the feasibility and safety of elective PCI without on-site cardiac surgery was progressively acknowledged in guidelines and practice (5-7). As an extensive body of evidence compared PCI to CABG, it has become apparent that these 2 modes of revascularization excel in distinct subsets of the population. CABG has remained the gold standard in patients with diabetes mellitus, altered ventricular function, complex lesions (i.e., SYNTAX score ≥23) multivessel disease, or complex left main disease (8). Conversely, advanced age, frailty or comorbidities, focal coronary lesions with SYNTAX score ≤22, acute myocardial infarction, or shock favor PCI (8).

Initial management of coronary artery disease by one technic does not preclude a subsequent use of the other one when facing evolution of the disease over time. Indeed, development of diffuse coronary lesions or recurrent in-stent restenosis, initially managed percutaneously, may ultimately lead to CABG revascularization. By opposition, late graft failure, a common complication of saphenous vein graft, is frequently treated by PCI, to prevent the 2-fold to 4-fold increased mortality of redo CABG (8,9).

In the last decades, several CABG technics have been developed to improve outcomes and/or reduce invasiveness. Generalization of arterial conduits was shown to provide better long-term patency than venous conduits (9). The aortic "no-touch" off-pump CABG technique was developed to avoid manipulation of the aorta and potential rupture of atherosclerotic plaque (10). Minimally invasive direct coronary artery bypass, robotic CABG, and hybrid coronary revascularization were also developed to reduce CABG invasiveness and shorten the on-pump period, and were associated in general with favorable outcomes (9). Nonetheless, these technical improvements have not spread out in clinical practice, being often confined to expert high-volume cardiac surgery centers. Subsequently, post-CABG complications, including but not limited to perioperative and early postoperative myocardial injury have remained a concern (9).

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Data on the incidence, risk factors, and management of these complications have been scarce. In this issue of the *Journal*, Alqahtani et al. (11) present the largest observational study to date on in-hospital post-CABG PCI. Using the Nationwide Inpatient Sample, the authors were able to include more than one-half million patients undergoing CABG from 2003 to 2014 in >1,000 U.S. centers. With this solid,

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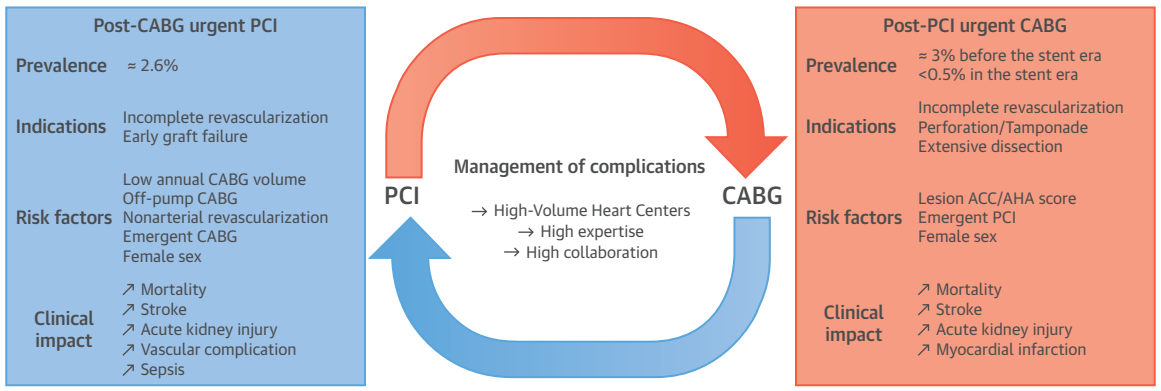
FIGURE 1 Summary Representation of the Complementarity Between PCI and CABG



ACC/AHA = American College of Cardiology/American Heart Association; CABG = coronary intervention bypass graft; PCI = percutaneous coronary intervention.

all-payer, administrative claims-based database, the authors describe rates of in-hospital post-operative angiography and PCI at 4.4% and 2.6%, respectively. Mirroring the average rate of post-PCI emergency CABG of 3% in the pre-stent era in the early 1990s, this report demonstrates an inversion of the paradigm, where PCI has become the backup procedure of CABG (2).

A second important finding of this study is the severe morbidity and mortality associated with post-CABG PCI, with a doubled risk-adjusted in-hospital mortality, as well as an increased risk of stroke, vascular complications and sepsis, resulting in longer in-hospital length-of-stay and an increase in health care costs. Again, these findings mirror the significant morbimortality associated with emergent CABG after failed PCI, reported many years ago (**Figure 1**) (3).

The present study provides a powerful statement for the need to identify and address modifiable risk factors of early coronary compromise following CABG. In this regard, low annual CABG volume may be one of the most important factor, which other identified risk factors may stem from. Indeed, numerous studies have previously reported an association between higher-volume of procedures and reduced in-hospital mortality, of note, for both revascularization techniques (12). Higher CABG volume may enhance surgeons' expertise leading to safer off-pump procedures in high-risk patients and larger use of arterial conduits, resulting in improved early and long-term outcomes (8,9).

Notwithstanding, this sound study is not exempt from limitations, as its administrative claims-based nature precludes from analyzing the results of the post-CABG coronary angiography. Thus, the exact diagnosis behind in-hospital post-CABG PCI (i.e., early graft failure or incomplete revascularization) remains unclear. Moreover, patients undergoing post-CABG PCI during a subsequent early readmission were not included. Finally, no conclusion can be drawn regarding the optimal revascularization strategy to adopt according to patients' characteristics and the causes of the myocardial injury. The adjusted lower risk of post-CABG PCI found in patients with diabetes mellitus, end-stage chronic kidney disease, or older age would warrant further exploration. Indeed, the impact on survival of noninvasive management of post-CABG coronary compromise in these frail patients remains undetermined.

In conclusion, despite this progressive reversal in the paradigm of coronary revascularization modalities, the objective has remained the same: improving quality and quantity of life for the patients. PCI and CABG are complementary techniques, and each one may alleviate the failure or complications of the other. In this setting, indication for coronary revascularization follows the presence of ischemia or necrosis, while patients' comorbidities and coronary lesion complexity will affect the heart team decision. The relatively high rate of in-hospital post-CABG PCI described in the present study argues in favor of expert heart centers with high volumes of both PCI and CABG to better manage all patients with coronary artery disease.

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