Editorial Comment

Acute Coronary Occlusion After Percutaneous Transluminal Coronary Angioplasty
Evolving Strategies and Implications

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In this issue of Circulation, Detre et al1 review the incidence and outcome of periprocedural coronary artery occlusion following percutaneous transluminal coronary angioplasty (PTCA) in the second phase of the National Heart, Lung, and Blood Institute’s (NHLBI) PTCA Registry. This registry examined the results in 1,801 patients managed during 1985–1986 with an initial PTCA not in the setting of acute myocardial infarction (MI) from 15 experienced centers. Periprocedural occlusion was observed in 122 (6.8%) patients, with 72% of occlusions occurring while the patient was still in the cardiac catheterization laboratory (4.9% incidence) and 28% of occlusions occurring outside the catheterization laboratory following initially successful PTCA (1.9% incidence). Independent predictors of periprocedural occlusion included the following: 1) patients at “high” surgical risk; 2) patients with acute coronary insufficiency; 3) patients with three-vessel coronary artery disease; 4) pre-PTCA coronary arterial diameter stenosis ≥90%; 5) dilatation of coronary artery segments with diffuse disease, multiple discrete lesions, intraluminal thrombus, or ones that supplied collateral flow to other vessels; and 6) presence of an intimal tear or dissection following PTCA.

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Periprocedural occlusion was managed with successful repeat PTCA in 49% of patients, with coronary bypass surgery (CBS) in 35% and medical management in 16%. The presence of significant arterial dissection was associated with a decreased likelihood of successful management with repeat PTCA. In patients with periprocedural occlusion, the incidence of acute MI was 40%, need for emergency CBS 32%, and hospital mortality 4.9%. At late (2-year) follow-up, patients with periprocedural occlusion had a higher incidence of death and MI than patients without occlusion, but it is important to recognize that this difference was largely confined to the initial hospital phase; following hospital discharge, the late incidence of death plus MI was virtually identical between the two patient groups. Patients discharged from the hospital after periprocedural coronary occlusion that was managed with successful redilatation had a slightly higher need for repeat revascularization (repeat PTCA or CBS) at 2 years.

The Present Study in Perspective

The findings from the NHLBI Registry provide important, timely, and valuable data and offer new insight into the problem of periprocedural occlusion following PTCA. While periprocedural occlusion was associated with a relatively high incidence of major in-hospital complications, it must be recognized that 1) only a small minority of patients experienced coronary occlusion (6.8%); 2) for the majority of patients who did not sustain a periprocedural occlusion, the incidence of acute MI (2%), emergency CBS (1.4%), and death (0.7%; 12/1679)1,2 were quite low; and 3) for all patients in the NHLBI Registry (1,801 patients), the incidences of MI, emergent CBS, and mortality were 4.3%, 3.5%, and 1%, respectively.2

These complication rates are comparable with those of other large recent series in which acute MI was observed in 1.6–2.7% of patients, emergency CBS was required in 1.6–2.7%, and mortality occurred in 0.1–0.8%.3–6 The long-term prognosis for hospital survivors of periprocedural occlusion in the NHLBI Registry was also similar to other reported late outcomes in similar patients, with favorable late prognosis.7–9 The independent predictors of periprocedural occlusion observed in the NHLBI Registry are similar to those reported in other series; other reported predictors of PTCA-related coronary occlusion have included dilatation of the right coronary artery as well as dilatation of eccentric or sharply angulated lesions.7,8,10–13

Out-of-Laboratory Coronary Occlusion

The problem of acute coronary artery occlusion occurring outside of the cardiac catheterization lab-
Coronary artery dissection is observed in the majority of patients destined to develop coronary occlusion following PTCA,7,9,14,16,17; the presence of periprocedural coronary dissection thus identifies a group of patients at increased risk of out-of-laboratory coronary occlusion. Black et al18 observed that 9% of PTCA-related coronary dissections resulted in late ischemic complications; predictors of ischemic complications included the presence of unstable angina, PTCA of total coronary occlusions, significant post-PTCA residual stenosis, and the presence of long dissections or retained extraluminal contrast. Madison et al19 observed that 28% of patients with complex coronary dissections developed late coronary occlusion.

Many out-of-laboratory post-PTCA coronary occlusions appear to be temporally related to subtherapeutic anticoagulation or recent discontinuation of heparin.14,16 Sustained (24–48 hour) heparin infusion may be of benefit in patients at particularly high risk of late coronary artery occlusion after initially successful PTCA (for example, those with extensive coronary dissection, presence of intracoronary thrombus, or prior acute occlusion in the catheterization laboratory successfully managed with repeat balloon dilatation). While Ellis et al20 found no benefit of sustained heparin infusion in preventing out-of-laboratory coronary occlusion after PTCA, this series specifically excluded patients with large coronary dissections. In the present Registry, out-of-laboratory coronary occlusion was as likely to be successfully managed with repeat PTCA as in-laboratory occlusion; to attain these excellent results with minimal myocardial damage, meticulous care and monitoring is essential following PTCA, with the ability for immediate transfer to the catheterization laboratory should evidence of acute coronary occlusion develop.

Changing Strategies in the Management of Periprocedural Occlusion and the Role of Emergent Coronary Bypass Surgery

The field of PTCA is rapidly changing, and the findings of the present Registry, in which the data are nearly 5 years old, must be placed in the context of current clinical experience. With increased operator experience and technological advances, the diversity of patients and complexity of lesions managed with PTCA has increased, but complication rates have actually decreased.3,21–23 Early series reported emergency CBS rates of over 5% following PTCA,3,4,22,24,25 yet recent series have observed rates of emergency CBS under 3%, as noted above. These changes are also reflected in the management of periprocedural occlusion. In early series, as many as 70% of patients with PTCA-related coronary artery occlusion required emergency CBS,26 whereas in later series reporting patients through 1986, only 24–55% of patients with periprocedural occlusion required emergency CBS, and up to 71% of patients were successfully managed with repeat PTCA.7–9,11,14 The results of these series are similar to those reported by the NHLBI Registry; more recent experience suggests still further changes in patient management strategies.

In review of the most recent 250 consecutive PTCA procedures (including patients with recent acute MI) performed at Los Angeles County–University of Southern California Medical Center in 1989–1990, we observed an 8% periprocedural coronary occlusion rate (60% in the catheterization laboratory and 40% out of the laboratory). While this incidence of occlusion is similar to the 6.8% incidence reported by the NHLBI 1985–1986 Registry,1 we were able to successfully manage 85% of occlusions with repeat PTCA, and emergency CBS was required in only 10% of patients with periprocedural occlusion. The overall incidence of emergency CBS in this recent series was only 0.8% (2 of 250 patients).

Reasons for the ability to successfully manage increasing numbers of patients with PTCA-related coronary occlusion without the need for emergency CBS is largely related to a broader array of devices and techniques available to the skilled interventional cardiologist in the current era, including 1) lower profile and more steerable dilatation systems that have enhanced the ability to successfully and safely negotiate and dilate complex coronary artery stenoses; 2) liberal use of antiplatelet agents before and during PTCA, which reduces major PTCA-related complications;27,28 3) careful monitoring of the status of heparinization during the procedure;29,30 4) management of intracoronary thrombus with liberal use of heparin and/or thrombolytic agents; and 5) use of prolonged balloon inflations (discussed below).

Coronary artery dissection is the predominant cause of PTCA-related coronary artery occlusion.7–9,14,16,17,19 The use of prolonged balloon inflations when coronary artery dissection is recognized can successfully restore and maintain arterial patency and can forestall the need for surgical revascularization in many patients.31,32 Availability of the perfusion balloon catheter has been a major advance in this area, permitting use of prolonged (often in excess of 10 minutes) balloon inflations while limiting the development of myocardial ischemia.31–33 Prolonged balloon inflation with limited myocardial ischemia may also be facilitated with the use of synthetic oxygenated fluorochemicals.34 High-risk patients may also be stabilized and supported with the use of full percutaneous cardiopul-
monary support systems.\textsuperscript{35,36} Future application of intracoronary stents,\textsuperscript{37} laser balloon angioplasty,\textsuperscript{38} and intracoronary atherectomy\textsuperscript{99} may further increase the ability to salvage initially failed angioplasty and diminish the need for emergency CBS.

Reducing the need for emergency CBS after unsuccessful PTCA is clearly desirable. In large series of patients undergoing emergency CBS after PTCA, mortality has ranged from 2\% to 15\%, and the incidence of Q wave MI from 21\% to 49\%.\textsuperscript{6,10,40-44} These results are significantly worse than those observed after elective CBS in stable patients.\textsuperscript{41,47} The present NHLBI Registry\textsuperscript{3} involves experienced centers, with surgeons skilled and experienced in the management of PTCA-related complications, performing large numbers of procedures, yet a 5\% mortality rate and 56\% incidence of MI was observed after emergency CBS in patients with periprocedural PTCA-related coronary artery occlusion. Measures to minimize myocardial oxygen requirements, including the use of percutaneous cardiopulmonary support and intraaortic balloon counterpulsation, may allow stabilization of the patient with abrupt coronary occlusion and safer preparation of the patient for emergency CBS.\textsuperscript{35,36} The ability to maintain distal coronary artery perfusion with the use of the coronary perfusion ("bailout") catheter may improve results of emergency CBS by reducing the incidence of perioperative MI and allowing increased use of the internal mammary artery as a bypass conduit.\textsuperscript{48} The most important factor in successful emergency surgical revascularization remains prompt restoration of myocardial perfusion and a coordinated effort between skilled cardiologists and skilled cardiac surgical teams.

Implications for Surgical Standby During PTCA

As PTCA is being used in increasing numbers of patients,\textsuperscript{21} and the need for emergency CBS after PTCA has been reduced to less than 2–3\% in many centers, the question of surgical standby for the performance of routine PTCA has come under question.\textsuperscript{49} While infrequent, the need for emergency surgical revascularization after PTCA remains largely sporadic and unpredictable; for this reason, PTCA should be performed in facilities with capabilities for rapid surgical support. A recent American College of Cardiology/American Heart Association Task Force report stated that "An experienced cardiovascular surgical team should be available within the institution for emergency surgery for all angioplasty procedures."\textsuperscript{50} The critical issue is one of the level of standby required for routine PTCA cases. In predictably high-risk patients (for example, planned complex dilatation, severe left ventricular dysfunction), presence of a complete surgical team and operating room in full readiness may be quite appropriate. For the majority of patients treated with PTCA, however, a lower level of standby seems appropriate. Such arrangements may include the presence of an open or soon-to-be-open operating room with a surgical team on call, use of the next available operating room and team, or other possibilities depending on the individual resources of a given institution. Many of these arrangements are made more practical with the development of an increasing range of available methods by which the interventional cardiologist can stabilize patients and maintain viability of ischemic myocardium in the cardiac catheterization laboratory. Whatever the arrangements made within the institution, it is the responsibility of the cardiologist performing PTCA to evaluate the potential risk of each procedure and to ensure that means exist for appropriately prompt emergency surgical revascularization if required. PTCA is of major clinical benefit in increasing numbers of patients; cooperative teamwork between cardiologists and surgical colleagues will ensure optimal care and will be in the best interests of patients.

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