Emergency Stenting for Acute Occlusion After Coronary Balloon Angioplasty

Ulrich Sigwart, MD, Philip Urban, MD, Svein Golf, MD, Urs Kaufmann, MD, Christian Imbert, Adam Fischer, MD, and Lukas Kappenberger, MD

Acute coronary artery occlusion complicates 2–12% of the balloonangioplasty procedures, and despite repeat angioplasty, emergency surgical revascularization is often necessary. We report our initial experience with the emergency implantation of endoluminal stents for acute vessel closure after coronary balloon angioplasty. Nine patients received one stent, and two patients received two stents during the study period. Implantation was technically successful in all patients; there were no deaths, no myocardial infarctions as evidenced by Q wave on the electrocardiogram, and no need for emergency surgery. One additional patient, not satisfying the study inclusion criteria, died 16 hours after stent implantation from left ventricular failure and intractable arrhythmias. Two patients in the study group had a moderate creatinine phosphokinase rise during the first 48 hours after implantation. During a median follow-up period of 3 months (range, 1–20 months), there have been no deaths and no need for elective coronary bypass surgery. One patient required emergency recanalization 3 months after implantation because of acute occlusion of the stented segment with limited myocardial infarction. Six patients have undergone control angiography, and none has developed chronic restenosis within the stented segment. For selected patients, coronary artery stenting appears to be a promising alternative to emergency bypass surgery after acute vessel occlusion during balloon angioplasty. (Circulation 1988;78:1121–1127)

Despite major improvements in equipment and operator skill, restenosis and acute vessel closure remain the main limitations of coronary balloon angioplasty, occurring in about 33% and 2–12% of procedures, respectively. The pathological mechanisms that underlie both these complications are as yet only partially understood. However, together with endothelial damage and thrombosis, it is generally agreed that localized dissection of the arterial wall, intimal flap formation, and elastic recoil of the distended arterial segment play a central role.

Current practice for treating acute occlusion usually consists initially of a repeated angioplasty aimed at “tacking down” the dissection flap, sometimes associated with the use of thrombolytic agents to deal with the thrombotic component of the obstruction. When these measures are insufficient to maintain a stable patent lumen, emergency bypass surgery is the only treatment recommended for persistent ischemia. Reperfusion (“bailout”) catheters often temporarily maintain coronary flow while the patient awaits surgery, but they do not constitute definitive management.

Emergency coronary bypass surgery after failed angioplasty is associated with an increased mortality and morbidity when compared with elective procedures. Previous studies report an incidence of myocardial infarction of 31–71%. Due to the unavoidable delay between vessel occlusion and surgical revascularization. In-hospital mortality varies between 0% and 15%. This emphasizes the need for a rapid, definitive, and reliable technique capable of reestablishing a stable patent lumen after balloon angioplasty-induced acute occlusion.

The use of intraluminal stents has been previously described by our group; we now report our initial experience with stenting for acute vessel closure after angioplasty.

Patients and Methods

Patients

In an ongoing, open, clinical observational study, 13 stents were implanted in 11 patients for acute vessel closure after balloon coronary angioplasty between June 86 and February 88. The study protocol was approved by the hospital ethics committee.
Some of the data pertaining to the first four patients in this series have been reported previously.\textsuperscript{13}

For all 11 patients, balloon angioplasty was performed according to current clinical practice with steerable balloon catheters. Patients received aspirin before the procedure and were fully heparinized. Acute vessel closure was treated with repeat angioplasty in all patients. Small amounts of intracoronary urokinase were infused in five patients to prevent clot from forming on the exchange guide wire, and a reperfusion catheter was used on two occasions.

Patients were considered for stent implantation if 1) they developed symptomatic occlusion after coronary angioplasty; 2) the response to repeat balloon angioplasty was unsatisfactory; 3) their coronary vasculature was considered suitable for stenting, that is, no important difference in diameter between proximal and distal portions of vessel segments to be stented, no branching into equal caliber vessels at stent site, no diffuse disease process, good distal run-off, and lesion at least 10 mm from main stem if in the left coronary artery; 4) they were potential candidates for emergency bypass surgery; 5) surgical standby was available; and 6) informed consent was obtained.

Patients were not considered suitable candidates for stenting if 1) they were not potential emergency bypass surgery candidates (i.e., small vessel, previous infarction in jeopardized territory, etc.); 2) a contra-indication to long-term anticoagulants existed; and 3) severe hemodynamic compromise was present.

**Methods**

The stent (Medinvent, Lausanne, Switzerland) has been described in detail previously.\textsuperscript{13} Briefly, it consists of a stainless steel alloy with a self-expanding mesh design (Figure 1). It is flexible along its long axis; its length for coronary implants varies between 15 and 30 mm; and its diameter is typically between 3 and 5 mm in the fully expanded state. For any given lesion, a stent is selected so that its fully expanded diameter is somewhat larger than the estimated normal lumen of the recipient vessel. It will then be stable once positioned and will exert a residual radial pressure on the arterial wall. Before implantation, a doubled-over membrane maintains the stent in a constrained and elongated position on the delivery system. This is introduced into the coronary artery through a standard 8F or 9F guiding catheter over an exchange guide wire. Retraction of the membrane allows the stent to be progressively released into the vascular lumen.

All implants were performed by the same operator as previously described.\textsuperscript{13} After the decision was made to implant the stent, all patients received up to 100,000 IU urokinase i.c. during 30–60 minutes. Heparin 5,000 IU i.v. was given just before implantation, and an infusion was conducted without interruption afterward, until oral anticoagulation was effective. Warfarin was then given for 3 months, and the dosage was adjusted to maintain an International Normalized Ratio (for thromboplastin time) of 2.3 or more. Calcium channel blockers, low-dose aspirin, and dipyridamole were also given. For the final six patients, sulfinpyrazone was added to this regimen.

**Results**

Eleven patients satisfying the inclusion criteria received 13 intraluminal stents because of acute occlusion. During the study period, seven other patients underwent emergency surgical grafting after a failed coronary balloon angioplasty (three did not satisfy the inclusion criteria, and four were operated on because either the stenting device or the operator was unavailable at the time of acute occlusion); thus, 11 (61%) of these 18 patients who required emergency revascularization were treated by stenting alone. The baseline clinical data of the 11 patients are given in Table 1. The indication for angioplasty was disabling angina in all patients, New York Heart Association Class II–IV for six patients and unstable symptoms with documented transient electrocardiographic changes at rest for five patients.

**Implantation**

Implantation was technically successful in all patients (Table 2). In one patient, a second stent was necessary to cover the entire lesion, and another patient received two stents for two distinct lesions. Coronary occlusion was intermittent in most patients because of redilation attempts, but median time from initial vessel closure to stent implantation and definitively reestablished flow was 55 minutes (range, 30–120 minutes). Stent implantation required about 5–10 minutes (preparation and flushing of delivery system, exchange over long wire, and implantation).
During the study period, an additional 66-year-old patient received a stent to his proximal left anterior descending coronary artery (LAD), although he did not satisfy the inclusion criteria. After an initially satisfactory LAD angioplasty, acute occlusion occurred 1 hour later when the patient had returned to the ward. Because the surgical team was no longer on stand-by duty, repeat dilatation was performed as soon as possible but did not establish stable patency, and the patient developed severe hypotension and arrhythmias. Although we had determined in our protocol that such a state of hemodynamic compromise constituted a contraindication, stenting was attempted as a last resort because no other option was available at the time. Because of radiographic maintenance work in the catheter laboratory, an important fluoroscopy failure occurred before and during the implantation phase; this further prolonged the period of ischemia and prevented optimal stent placement to cover the entire lesion (time from onset of ischemia to stent implantation was 90 minutes). After the procedure, the patient developed recurrent ventricular fibrillation, deteriorated further, and finally died 16 hours later from intractable ventricular arrhythmias. No necropsy was performed.

In-Hospital Follow-up

The median hospital stay after stent implantation was 4 days (range, 2–20 days). There were no deaths, no coronary bypass surgery performed, and no myocardial infarctions as evidenced by Q wave on the electrocardiogram. Serial creatinine phosphokinase levels were measured for all patients and were found to peak above twice the normal value in two patients. In one patient, this was related to the temporary occlusion of a diagonal branch induced by balloon angioplasty. One patient required blood transfusion because of bleeding at the femoral puncture site.

Long-term Follow-up

The median follow-up time was 3 months (range, 1–20 months). There have been no deaths, and no elective coronary bypass surgery was performed. Clinically, all patients have remained improved, and seven have remained asymptomatic without further intervention. Six patients underwent angiographic control a median of 5 months after implantation (range, 3–7 months). There was one instance of late acute occlusion of the stented segment (patient 2), but no instance of significant (>50% luminal diameter reduction) restenosis within the stented segment. No bleeding complication was observed during the follow-up period.

Patient 1 developed recurrent angina after two-vessel angioplasty followed by emergency stenting of the LAD and was shown to have developed restenosis in the right coronary artery. A second stent was implanted electively in the right coronary artery. The patient was asymptomatic 20 months after the second implant, and angiographic control after 11 months has shown both stented segments to be free of restenosis. Patient 2 underwent surgery for a femoral pseudoaneurysm 3 months after stent implantation. Acute myocardial ischemia developed in the immediate postoperative phase, and coronary angiography showed this to be due to acute occlusion of the stented vessel. Despite successful treatment with urokinase and balloon recanalization, some degree of myocardial damage occurred. Four months after this episode, the stent was angiographically shown to have remained open without restenosis, and the patient was free of angina. Patient 7 developed unstable angina 3 months after angioplasty of two LAD stenoses, with stenting of the proximal lesion after acute occlusion at that level. Angiography showed an excellent result of stenting together with restenosis of the second lesion 10 mm distal to the stented segment. This was successfully treated by repeat balloon angioplasty, and a stress test performed afterward was negative.

Discussion

This constitutes the first report on emergency coronary artery stenting for acute occlusion after balloon angioplasty. It demonstrates that for selected patients stenting is technically feasible, reliably prevents myocardial infarction in most instances, and is associated with an acceptable incidence of complications. Although the follow-up is not yet complete, initial results are encouraging because no restenosis within the stented segment has yet been observed. These results appear similar to the reduction in the restenosis rate obtained when elective stenting is used for the prevention of restenosis.15

With the current design of the stent, appropriate patient selection remains an essential factor. If systemic hypotension or poor flow through the stent can be anticipated, implantation is probably contraindicated at the present time. This point is underlined by the fatal outcome observed in the patient who received a stent even though his state of severe hemodynamic compromise was considered a contraindication to implantation. With the current device, we believe that implantation should only be attempted if it can be performed without undue delay in hemodynamically stable patients.

The stainless steel stent undeniably predisposes the patient to local thrombosis. Meticulous anticoagulation together with the administration of antiplatelet agents is, therefore, critical during the first 3 weeks. The instance of late acute occlusion 3 months after implantation in one patient is a cause for concern. Experimental evidence suggests that endothelialization is essentially complete within 3 weeks, but the process may be slower in diseased human coronary arteries.13 Also, stents could predispose patients to increased vasomotor tone and spasm for an unpredictable period.

The effectiveness of stenting for acute coronary occlusion points to the central role of dissection and subintimal hemorrhage causing lumen obliteration.
FIGURE 2. Arteriograms of right coronary artery of patient 4, 57 years old, with New York Heart Association Class IV angina and single-vessel disease. Panel A: Persisting tight stenosis in the middle of the vertical portion of the right coronary artery immediately after balloon angioplasty. Panel B: Occlusion with chest pain, and electrocardiographic changes occurred a few minutes later. Panel C: Implantation of two stents was successful, and the angiographic appearance was satisfactory. Panel D: Control angiography 4 months later showed no significant change.
However, in patients where intraluminal thrombus appears to be the central mechanism involved, the addition of a metallic stent could theoretically exacerbate the pathological process rather than have a beneficial effect.

Technically, emergency implantation is not different from elective stenting, and high-quality fluoroscopy is a prerequisite for proper placement. The usual absence of adequate antegrade flow in the setting of acute occlusion requires extra operator skill: correct positioning of the stent across the lesion can be a problem because the lack of visible side branches makes spatial orientation more difficult. The time lag between occlusion and stenting should be kept as short as possible to avoid major myocardial damage. Ideally, this would require a sufficient range of stents of various dimensions to be on hand. In the present study each device was delivered to our laboratory from the manufacturer only after the decision was made to stent a lesion; the average time, therefore, from the first onset of vessel closure to stent implantation was longer than it ideally could have been. Nevertheless, it allowed complete prevention of myocardial necrosis in more than 80% of patients.

It is too early at this stage to attempt a full comparison with emergency surgery, but it appears that in properly selected patients myocardial salvage can be achieved with good long-term results and a short hospital stay. Sixty-one percent of patients (11 of 18) needing emergency revascularization after failed angioplasty in our institution underwent stenting during a period of 19 months. Improvements of the stent design are currently being investigated to decrease initial thrombogenic properties of stent devices and improve long-term results. It seems reasonable to assume that, in the near future, a substantial proportion of patients in need of emer-

**Table 1. Baseline Clinical Data**

<table>
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<tr>
<th>Patient</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Symptoms</th>
<th>Vessels (n)</th>
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<th>PTCA</th>
<th>Location of patient</th>
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Vessels, number of vessels with significant lesions; LVEF, left ventricular ejection fraction; PTCA, percutaneous transluminal coronary angioplasty; location of patient, location at time of acute occlusion; urokinase, administration of urokinase; reperfusion, use of reperfusion catheter to treat acute occlusion; NYHA II, III, IV, New York Heart Association Class II, III, and IV for angina; LAD, left anterior descending coronary artery; RCA, right coronary artery.

**Table 2. Implant and Follow-up Data**

<table>
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<tr>
<th>Patient</th>
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<th>Unconstricted diameter (mm)</th>
<th>Length (mm)</th>
<th>Complications</th>
<th>Creatinine phosphokinase (units/ml)</th>
<th>Time (mo)</th>
<th>Follow-up</th>
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Time, time between initial occlusion and stent implant; creatinine phosphokinase, maximum value after stent implantation; time, time to follow-up; symptoms, anginal symptoms at time of last follow-up visit; LAD, left anterior descending coronary artery; RCA, right coronary artery; occlusion, occlusion of first diagonal branch; hematoma, inguinal hematoma requiring blood transfusions; NYHA II, New York Heart Association Class II for angina.
gancy revascularization after failed balloon angioplasty will be able to benefit from intraluminal stenting instead of surgery as part of normal clinical practice.

References

Key Words • percutaneous transluminal coronary angioplasty • acute vessel occlusion • stenting • emergency coronary bypass surgery
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