Short Communications

Coronary Artery Stenting with High-Pressure Post-Dilation Followed by Adjunctive Thrombolysis after Failed Coronary Angioplasty for Acute Myocardial Infarction: Report of Three Cases

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Summary: We successfully implanted coronary stents into refractory reoccluded lesions after failed coronary angioplasty in three patients with acute myocardial infarction (AMI). Lesion location was the proximal left anterior descending coronary artery in two patients and the dominant right coronary artery in one patient. The reference diameters of the lesions were 3.64, 3.33, and 3.50 mm, respectively. A stent with a luminal diameter of 3.0 mm was implanted in all patients. Poststenting dilation of the stent was performed at high pressure (18 atm), and urokinase was administered immediately thereafter. Heparin was administered for 24 h with maintenance of activated coagulation time within 180–200 s. Warfarin was then administered to keep the international normalized ratio within 2.5–3.5. Luminal diameters immediately after stenting were 3.14, 2.89, and 3.26 mm, and those at 1 month after stenting were 3.09, 2.81, and 3.12 mm, respectively, indicating good patency. Our experience in these cases suggests that coronary stenting can be applied after unsuccessful coronary angioplasty in selected patients with AMI. The present report includes informative reference data on diameter, postdilation, adjunctive thrombolytic agent administration, and adequate anticoagulation therapy in coronary stenting in this acute application.

Key words: reperfusion therapy, mechanical dilation, recanalization, coronary artery disease

Introduction

Coronary angioplasty has recently been applied in attempts to recanalize the occluded coronary artery in patients with acute myocardial infarction (AMI).^{1–3} The incidence of reocclusion due to coronary dissection and/or thrombosis after emergency coronary angioplasty ranges from 5 to 15%.^{1–3} There are only three reports on the application of coronary stenting to recanalize a reoccluded artery after unsuccessful coronary angioplasty in AMI.^{4–6} The strategy in coronary stenting, including consideration of the type of stent, anticoagulation method, lesion status, adjunctive thrombolysis, and poststenting dilation, has not been established. Further case reports are thus essential. We describe herein our experience in coronary artery stenting for a reoccluded coronary artery after unsuccessful coronary angioplasty in three patients with AMI.

Case Reports

Case No. 1

A 63-year-old man was admitted with anterior chest pain which had started 2 h before hospitalization. Admission electrocardiography (ECG) disclosed ST-segment elevation in leads I, aVL, and V_{1–6}. Emergency coronary angiography revealed complete occlusion of the proximal portion of the left anterior descending coronary artery without collateral circulation (Fig. 1A).

After measurement of the approximate reference luminal diameter of the lesion on video display by ruler method, coronary angioplasty with a 3.0 mm balloon catheter (Edge Balloon Catheter®, Advanced Cardiovascular System, Santa Clara, California) was attempted, but it failed to establish stable recanalization, and reocclusion ensued. Prolonged balloon

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FIG. 1 Serial angiograms of the left coronary artery in Case No. 1. (A) Total occlusion of the proximal left anterior descending coronary artery prior to angioplasty. (B) Subtotal reobstruction with coronary dissection after coronary angioplasty. (C) Marked improvement in the lumen patency following stenting. (D) Preserved lumen diameter seen at 1 month after stenting.

inflation for 10 min with a 3.0 mm diameter balloon (Lifestream Perfusion Balloon Catheter®, Advanced Cardiovascular Systems) did not maintain patency of the infarct-related artery. Intracoronary administration of 4.8×10^5 units of urokinase did not succeed in stable reperfusion (Fig. 1B). Finally, after placement of a guide wire suitable for introduction of the stent (Hi-Torque Extra S'PORT .014®, Advanced Cardiovascular Systems), a coronary stent 3.0 mm in diameter with stent delivery balloon (Palmaz-Schatz Stent® with The Johnson & Johnson SDS system, Johnson & Johnson International Systems, Warren, New Jersey) was implanted into the lesion. This was the only stent available to us at that time. After implantation, the stent was further dilated with the same perfusion balloon as that used before stenting at 18 atm for 1 min, and urokinase (2.4×10^5 units) was then administered intracoronarily. The final coronary angiography revealed stable reperfusion (Fig. 1C). The reference diameter of the infarct-related artery on cinefilm was 3.64 mm. The lesion was now 3.14 mm in nominal diameter, and there was a 14% luminal reduction. Heparin was administered intravenously for 24 h, maintaining activated coagulation time within 180 and 200 s. Warfarin was then given to maintain international normalized ratio (INR) between 2.5 and 3.5.

Follow-up cardiac catheterization performed 1 month after stenting disclosed 3.09 mm diameter and 15% stenosis in the lesion (Fig. 1D), with left ventricular ejection fraction of 48% and hypokinesis of the anterolateral wall.

Case No. 2

A 64-year-old woman was admitted with onset of chest pain 2.5 h previously. Electrocardiography disclosed ST-segment elevation in leads V₂₋₆. Coronary angiography revealed subtotal occlusion of the proximal portion of the left anterior descending coronary artery without angiographically visible collaterals.

Coronary angioplasty with a 3.0 mm balloon catheter (Edge Balloon Catheter) resulted in a large dissection without antegrade flow. Prolonged balloon inflation for 10 min with a 3.0 mm balloon (Lifestream Perfusion Balloon Catheter) did not maintain patency of the infarct-related artery. Finally, after changing of the guide wire (Hi-Torque Extra S'PORT .014), coronary stenting with a 3.0 mm Palmaz-Schatz stent with stent delivery balloon was performed, and antegrade flow was established immediately. Poststenting dilation of the stent was performed using the same perfusion balloon at 18 atm for 1 min, and urokinase (2.4×10^5 units) was infused into the left coronary artery. The reference diameter of the infarct-related artery on cinefilm was 3.33 mm. Final diameter and percent stenosis of the lesion were 2.89 mm and 13%, respectively. For maintenance of activated coagulation time between 180 and 200 s, heparin was administered intravenously for 24 h, followed by warfarin administration to maintain INR at 2.5–3.5.

Coronary angiography performed 1 month after stenting disclosed a 2.81 mm diameter and 15% residual stenosis. Ventriculography revealed 46% ejection fraction.

Case No. 3

A 68-year-old man was hospitalized 1.5 h after onset of severe substernal pain. Admission ECG disclosed ST-segment elevation in leads II, III, and aV_F. Subtotal obstruction of the proximal portion of the right coronary artery was demonstrated by coronary angiography, and dominance of the right coronary artery was observed.

Coronary angioplasty was attempted using a 3.0 mm diameter balloon catheter (Edge Balloon Catheter). Reocclusion associated with coronary dissection occurred after the balloon inflation. Prolonged balloon inflation for 10 min with a 3.0 mm diameter balloon (Lifestream Perfusion Balloon Catheter) and intracoronary administration of 1.8×10^5 units of urokinase did not relieve the stenosis. A coronary Palmaz-Schatz stent 3.0 mm in diameter with the same stent delivery balloon was implanted. Additional dilation was performed with the same perfusion balloon catheter at 18 atm for 1 min. Urokinase (2.4×10^5 units) was administered through the coronary guiding catheter. Finally, stable reperfusion was established. The reference diameter of the infarct-related artery on cinefilm was 3.50 mm. The final diameter and percent luminal reduction of the lesion were 3.26 mm and 7%, respectively. After termination of catheterization, heparin was administered intravenously for 24 h to maintain activated coagulation time within 180 and 200 s. Warfarin was then given, and INR remained within the range of 2.5–3.5.

One month after the stenting, 3.12-mm diameter with 11% residual stenosis and 52% left ventricular ejection fraction were observed by follow-up catheterization.

Discussion

Our experience in these three cases suggests that coronary stenting could be an appropriate strategy for recanalization after unsuccessful coronary angioplasty in selected patients with AMI. Our cases had certain common characteristics, including a large perfusion area of the infarct-related artery, lesion reference diameter of approximately 3.00 mm, minimal angiographically demonstrated thrombus at the lesion, and failure to relieve recurrent reocclusion by any other technique.

Although the relative advantages of coronary angioplasty and thrombolysis for the treatment of AMI have not been determined, coronary angioplasty has some advantage in some applications,¹⁻³ especially in cardiogenic shock.⁷ The patency of the infarct-related artery is one of the major prognostic factors in AMI.^{8,9} Although the efficacy of coronary angioplasty for AMI has been reported, reocclusion after angioplasty inevitably occurs with an incidence of 5–15%.¹⁻³ Indeed, since 1985, we have performed coronary angioplasty for AMI in a total of 530 patients with similar reocclusion rate. Methods affording relief of reocclusion after conventional reperfusion therapy are thus essential. In our patients, prolonged balloon inflation and urokinase administration failed to afford stable reperfusion. Moreover, the coronary artery involved perfused a large area of the myocardium. Furthermore, the lesion location was appropriate for introduction of a stent. Therefore, it was suspected that persistent occlusion of the lesion would produce serious hemodynamic deterioration. In accordance with these findings and the lesion status, we decided to attempt coronary stenting in these patients.

Since the introduction of coronary stenting in our catheterization laboratory for the treatment of selected patients with stable angina in an elective setting, we have performed emergency coronary angioplasty for AMI in 89 patients. Recurrent reocclusion occurred in 10 patients, with coronary stenting performed in the 3 patients described herein. In 5 of the 10 pa-

tients, prolonged balloon inflation produced stable reperfusion, but in 2 patients it did not maintain patency. We did not attempt coronary stenting in these two patients for a number of reasons: the lesion was not suitable for introduction of a stent, a relatively small perfusion area was affected by the lesion, and hemodynamic stability was preserved. These exclusion criteria indicate that lesion location would be a major indicator in the selection of coronary stenting in an acute setting.

Thrombus formation is well known to be a major problem after coronary stenting. Thrombus formation is inversely related to lumen diameter after stenting.^{10,12} In our patients, the reference diameter of the lesion ranged from 2.89 to 3.26 mm, and in each of them a stent of 3.0 mm in diameter was used. Moreover, before stenting, angiographically demonstrated intracoronary thrombus formation was negligible. These findings suggest that a reference diameter of approximately 3.0 mm with minimum intracoronary thrombus is likely to result in a patent lesion that is free from thrombosis post stenting.

Poststenting dilation with high pressure was performed in all patients. The efficacy of high-pressure poststenting dilation has been reported in elective coronary stenting.¹³ Adequate, smooth, and rigid dilation at high pressure may contribute to patency after the stenting.

Urokinase was administered intracoronarily immediately after the post-stenting dilation. Heparin was administered intravenously for 24 h, maintaining activated coagulation time within 180 and 200 s, and warfarin was then given, maintaining the INR within 2.5–3.5. Although a recommended level of anticoagulation therapy has been reported in elective coronary stenting,¹⁴ there have been no reports regarding the degree of anticoagulation therapy in this acute setting. Our experience suggests that this adjunctive thrombolysis and anticoagulation therapy would be sufficient to prevent thrombosis in the stent.

Because we attempted coronary stenting in only three cases (though favorable outcome was achieved in all patients), no conclusion regarding the success rate is possible. There are three reports regarding a total of 14 patients who underwent coronary stenting for AMI.⁴⁻⁶ The patient characteristics and procedures described in these and the present reports are summarized in Table I. Reocclusion did not occur in our

TABLE I Previously reported and present cases

Reference (No.)	Number of patients	Stent type	Inflated diameter (mm)	High-pressure postdilation	Thrombolytic agent administration after stenting	Reocclusion
Wong and Wong (4)	3	Palmaz-Schatz stent	3.5, 4.0, 3.5	—	+	—
Walton <i>et al.</i> (5)	1	Cook flex stent	4.0	—	—	—
Ahmad <i>et al.</i> (6)	10	7, Palmaz-Schatz stent 2, Gianturco-Rubin stent 1, Palmaz-Schatz, Gianturco-Rubin, and 6 Micro Stent PL (triple stents implantation)	Not reported (mean post implanted diameter; 3.32 ± 0.92 mm)	—	—	3
Present report	3	Palmaz-Schatz stent	3.0, 3.0, 3.0	+	+	—

patients, although the lumen diameter of the implanted stents seems to have been smaller than those in the patients in the reported studies. Both postdilation with high pressure and adjunctive administration of thrombolytic agents were applied in all our patients. Reocclusion was observed in three of eight patients whose status was described by Ahmad *et al.*⁶ None of these eight patients received postdilation with high pressure or adjunctive thrombolysis. Although no conclusive statement can be made because of the small number of cases presented in each report, we suggest that postdilation with high pressure followed by adjunctive thrombolysis may have contributed to favorable results without hemorrhagic adverse effects in our patients, despite the relatively small lumen diameter of the stents implanted. Various types of stents were used in the reported cases, and it is not clear what type(s) of stent is most appropriate for AMI, although we found that the Palmaz-Schatz stent at least was useful in carefully selected patients with AMI.

Conclusion

Coronary stenting can be applied after failed coronary angioplasty in patients with AMI. The lesion reference diameter, postdilation with high pressure, adjunctive thrombolytic agent administration, and adequate anticoagulation therapy are all thought to be important factors affecting the success of the procedure.

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