less resistance. The implantation of stents can prevent the severe recoil and reduce the high reocclusion rate observed after balloon dilatation of these chronic obstructions.

This case report illustrates the application of the laser guide wire and multiple stents for the treatment of chronic total occlusion and exemplifies the importance of ultrasound guidance during stent deployment in these arteries in which long, diffusely diseased, and dissected segments must be covered by multiple stents.

A 50-year-old man was treated with systemic thrombolytic therapy in December 1992 for an inferior myocardial infarction. Over the next months he had recurrent exertional angina. Coronary angiography showed a large, dominant right coronary artery (RCA) with a 100% proximal occlusion (Fig. 1) and a distal segment filled by collaterals originating from the left coronary system. A conservative treatment was initially chosen on the basis of the presence of severe hypokinesia of the inferior wall, the technical complexity of the percutaneous treatment of the 2 cm-long occlusion, and the favorable prognosis (single-vessel disease). An attempt at percutaneous revascularization was decided 18 months after the detection of a complete coronary occlusion because of the persistence of symptoms on effort despite optimal medical therapy. The presence of residual ischemia was objectively documented with a bicycle exercise stress test (angina and 2 mm ST depression in the anterior leads at 220 W). Multiple attempts to cross the occlusion with conventional and stiff angioplasty guide wires were unsuccessful despite optimal coaxial backup support from the guiding catheter (left Amplatz 3, Cordis Corporation, Miami) and from a balloon advanced to the stump of the occlusion. Therefore it was decided to attempt recanalization of the RCA by means of a specially designed 0.018-inch 300 cm-long steerable guide wire (Prima Total Occlusion Device, model 018-003, Spectranetics, Colorado Springs, Colo.). Contrast injection into the left anterior descending coronary artery (LAD) allowed visualization of the distal RCA segment via collaterals. Two orthogonal views were filmed and were used to confirm the central position of the laser guide wire during activation of the laser. Another method used to ensure a central position of the guide wire during active firing was the advancement of a 2.5F support catheter (Spectranetics) over the wire and up to the occlusion. The activation of the laser guide wire at a fluence of 60 mJ/mm² and with a pulse repetition rate of 25 Hz was performed with a CVX 300, 308 nm, XeCl excimer laser generator (Spectranetics) and resulted in a successful recanalization of the occlusion. Because it was impossible to cross the lesion with a conventional angioplasty balloon, a 1.4F excimer laser catheter (1.4 Vitesse-C Rapid Exchange, Spectranetics) was successfully advanced over the laser guide wire by using a fluence of 50 mJ/mm² at a pulse repetition rate of 25 Hz. After multiple subsequent balloon dilatations with 2.5 mm, 3.0 mm (35 mm-long Speedy Plus, Schneider, Zurich, Switzerland), and 3.5 mm balloons (40 mm-long Streak, ACS Temecula, Calif.), angiography revealed a patent vessel with evidence of a long spiral dissection (type D NHLBI) (Fig. 2, A). This dissection was treated by deploying two sequential unconstrained-diameter 6 and 5.5 mm Wallstent (Schneider, Zurich, Switzerland) stents from the ostium to the mid segment of the vessel (Fig. 3). The next angiographic evaluation showed a satisfactory improvement in the lumen of the stented segment with a moderate overlap of the two stents. However, residual dissection and severe stenosis remained in the distal nonstented portion. Two additional 15 mm-long Palmaz-Schatz stents (Johnson & Johnson Interventional Systems, Warren, N.J.) were implanted with a 35 mm balloon (3.5 mm-diameter Speedy Plus, Schneider) at 9 atm. The result ap-

Fig. 1. RCA angiogram shows total proximal occlusion after a large right ventricular branch. Mid distal segment was filled by collaterals originating from left coronary system.
Fig. 2. **A**, Cineangiogram of same artery as in Fig. 1 after successful perforation of occlusion with excimer laser and adjunctive balloon dilatation. Note long spiral dissection in proximal segment. **B**, RCA is delineated without contrast medium by presence of five sequential stents from origin to crux (from proximal to distal two Wallstent stents, the more radiopaque Applied Vascular Engineering stent, and two Palmaz-Schatz stents). **C**, Final angiographic result obtained after additional IVUS-guided high-pressure dilatation.

Fig. 3. Three-dimensional reconstruction of proximal mid RCA after implantation of two sequential Wallstent stents. Longitudinal display of vessel is shown (mid left). **Upper left**, Corresponding measurements of cross-sectional areas (lower line) and minimal lumen diameter (MLD, upper line). These two modalities of display and the corresponding image in lumen cast format (lower left) demonstrate that regular lumen has been achieved after stent implantation and high-pressure dilatation. Presence of circular lumen and residual plaque compressed by stent struts can be observed at upper right (transverse view) and lower right, where cylindric reconstruction of artery is presented in “clamshell” view.
Fig. 4. Upper left, Transverse view of Palmaz-Schatz stent shows incomplete stent expansion with >50% residual cross-sectional area of stenosis (CSA St) and elliptic distortion of lumen. Position of displayed cross-section is shown in diameter function of longitudinal view (upper right). Lower left, Ultrasonic cross-section in same position after high-pressure balloon dilatation (lower right) shows more circular lumen with reduction in percentage of residual cross-sectional area stenosis.

peared to be angiographically successful with the exception of a short segment with diffuse haziness and residual stenosis in the mid RCA. For a better evaluation of the cause of this angiographic finding, an intracoronary ultrasound study was performed with a 2.9F, 30 MHz ultrasound catheter (Microview, CVIS, Sunnyvale, Calif.). An on-line three-dimensional reconstruction was performed after mechanical pullback at a constant speed of 1 mm/sec. The cross-sectional area of the segment evaluated was measured with an automated contour detection algorithm based on acoustic quantification of backscatter of the blood pool and coronary wall (Echoquant, Indec Systems Inc., Capitola, Calif.). Intravascular ultrasound (IVUS) clearly showed the presence of an incomplete stent expansion, with a residual stenosis and an elliptical distortion of the lumen in the distal segment of the Palmaz-Schatz stent (Fig. 4). In particular, the longitudinal display of the distal stented segment offered a rapid visual estimate and quantitative assessment of the inadequate stent expansion. More proximal, a nonstented 7 mm–long segment with a residual wall dissection was observed between the distal end of the Wallstent stent and the proximal end of the Palmaz-Schatz stent. In that segment, a 4 mm–long stent (Applied Vascular Engineering, Edmonton, Canada) was deployed with a 4.0 mm balloon; stent overlapping was avoided. Further high-pressure dilations of the two Palmaz-Schatz stents with a 4.0 mm balloon (20 mm–long Speedy Plus, Schneider) at 16 atm were performed, and the proper expansion of all five stents was confirmed by IVUS (Figs. 2, B and C, and 4).

Attempts to recanalize chronic total occlusion with conventional guide wires are hampered by a low immediate success rate (<60%) and a high reocclusion rate (>20%). To improve the results obtained by conventional transcatheter therapy in this common pathologic condition, specially designed guide wires (Magnum Wire, Schneider, Zurich, Switzerland) or rotational systems (Rotacs, Oscor Medical Corp., Palm Harbor, Fla.) have been developed. The method of recanalization of chronic total coronary occlusion by laser energy and a specially designed steerable laser guide wire has the potential advantage to cross any type of long, chronic fibrotic occlusions. To minimize the risk of vessel perforation, it is essential to maintain the device in a central position in the occluded segment of the vessel by using orthogonal views and contralateral injections during activation of the laser. In the 35 consecutive patients with chronic total coronary occlusion, the lesion could be successfully crossed with conventional systems in
only 13 (37%) cases. The percentage of success could be increased to 69% of cases (24 of 35) after a second attempt with the laser guide wire. There were two cases of wall perforation (2/22; 9%), both treated conservatively. After successful perforation of the lesion with these guide wires, it is common experience that laser energy delivered by laser catheters is necessary to create a channel in the hard fibrotic tissue to allow positioning of a balloon catheter. Balloon dilatation alone rarely achieves a satisfactory angiographic result in these long-standing occlusions, and it appears reasonable to complete these interventions with intracoronary stenting.

IVUS provides a circumferential high-resolution image of the vessel lumen and wall and clearly demonstrates the location of the highly echogenic stent struts. Recent studies have suggested that IVUS can facilitate stent deployment by means of high-pressure dilatations and that this technique can reduce stent thrombosis and long-term restenosis. The three-dimensional reconstruction of ultrasound images gives a clear and rapid overview of the segment of interest. In this case in particular it was possible to visualize the longitudinal profile of the two distal underdilated Palmaz-Schatz stents and to identify the segment with the minimal cross-sectional area requiring additional treatment. The three-dimensional reconstruction also provided accurate information regarding presence and length of the nonstented segment lying between the Wallstent and Palmaz-Schatz stents and facilitated the selection of the stent length required to avoid overlapping of the stents. In conclusion, the case described emphasizes the usefulness of a new laser guide wire to cross chronic total coronary occlusions and illustrates the importance of on-line IVUS three-dimensional reconstruction in guiding complex procedures of multiple stent deployment.

REFERENCES


Stand-alone stenting of the left main coronary artery and 16-month patency despite sepsis and complicated hospital course

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Stents are being used in coronary-disease patients for emergency management of abrupt vessel closure after angioplasty and for prevention of coronary restenosis after angioplasty. However, little data are available concerning stent placement in the left main coronary artery. We recently encountered a case whereby emergency stenting was performed in the left main coronary artery of a patient with a complicated hospital course who had been monitored without coronary bypass surgery for well beyond 1 year.

A 46-year-old Chinese male technical worker with angina (New York Heart Association functional class III) and risk factors of hypertension and heavy smoking was admitted for percutaneous transluminal coronary angioplasty (PTCA). He also had a history of renal disease with elevated serum creatinine of 253 µM/L (normal 82 to 126). A recent coronary angiogram revealed 70% stenosis of the left anterior descending, and multiple ectactic lesions of the left circumflex artery. PTCA of the right coronary lesion was performed first and was successful and uneventful. Because the left circumflex artery branched off the curvaceous left main artery at a right angle, the left Amplatz guiding catheter was used to support balloon angioplasty of the left circumflex lesions, which were also dilated successfully. The patient had no symptoms and was sent to the coronary care unit for post-PTCA monitoring. However, 2 hours later he began to have chest pain; marked electrocardiographic (ECG) ST-segment elevation in leads I, aVL, V4 through V6; and premature ventricular contractions. He was brought back to the cardiac catheterization laboratory. A dissection with subintimal hematoma was seen in the left main artery, but it did not appear to obstruct blood flow (Fig. 1, A). The blood pressure was 140/70 mm Hg. Urgent coronary bypass surgery was planned. However, while waiting there was rapid progression of the dissection and hematoma, with the whole left coronary flow severely compromised (Fig. 1, B). The patient had severe chest pain, and systolic blood pressure suddenly plum-