The outcome of percutaneous coronary intervention in patients with InStentrestenosis who failed intracoronary radiation therapy.

Ajani AE, Waksman R, Cheneau E, Cha DH, McGlynn S, Castagna M, Chan RC, Satler LF, Kent KM, Pichard AD, Pinnow E, Lindsay J.

This study reports the outcome of patients who failed intracoronary radiation therapy (IRT) for the treatment of in-stent restenosis (ISR). Intracoronary radiation therapy has demonstrated a reduction in the recurrence rate of restenosis for patients with ISR. However, 10% to 30% of these patients require repeat intervention to the irradiated site. Of 961 patients who were assigned to gamma or beta radiation for the treatment of diffuse ISR, we evaluated the outcome of 282 (29%) consecutive patients who failed IRT and compared them with the 679 (71%) patients who had successful IRT. For patients who failed radiation, the mean time to the first target vessel revascularization (TVR) was 173 ± 127 days after the index procedure and the total duration of follow-up was 494 ± 304 days. Patients who failed IRT were younger (60 ± 10 vs. 63 ± 11 years, p = 0.002) and had a higher incidence of restenting (51% vs. 41%, p = 0.003). The majority (55%) of the restenotic lesions after IRT failure were focal (≤10 mm), with a mean lesion length of 11.9 ± 1.9 mm. Of the 257 patients who had subsequent TVR after failed IRT, 68 (26%) underwent coronary artery bypass grafting and 189 (74%) underwent percutaneous coronary intervention using balloon in 61%, restenting in 26%, atheroablation in 11%, and the cutting balloon in 2% of cases. At six months, 6% of patients died, 1% had Q-wave MI, 17% had repeat TVR, and the overall rate of major adverse cardiac events was 21%. The predominant angiographic pattern of lesions in patients who failed IRT is focal restenosis, with these lesions responding well to conventional revascularization methods.
Mechanisms of restenosis after coronary intervention. Difference between plain old balloon angioplasty and stenting.

Nakatani M, Takeyama Y, Shibata M, Yorozuya M, Suzuki H, Koba S, Katagiri T.

BACKGROUND: Restenosis after coronary intervention remains an unsolved and important clinical problem. We histologically examined the mechanism of restenosis after both balloon injury and stenting. METHODS: Coronary arteries of swine were subjected to balloon injury and stenting. Next, just after stenting or at 7, 14, or 28 days, the animals were sacrificed for the evaluation by morphometric analysis, histological observation, and immunostaining. RESULTS: The neointimal area peaked at 14 days in the balloon injury group (BG) and increased linearly up to 28 days in the stent group (SG). At 28 days, the total vascular area in the BG was reduced to 78% of the control values. In the SG, the total vascular area remained enlarged. According to the phenotypic analysis, the vascular smooth muscle cells (VSMCs) in the neointimal area at 28 days were the contractile type in the BG and the synthetic type in the SG. Proliferating cell nuclear antigen (PCNA) and macrophage–positive cells were not observed in neointima in the BG at 28 days, whereas they were observed around the stent struts in the SG. In addition, numerous inflammatory cells, such as neutrophils and eosinophils, were also present in the SG. CONCLUSIONS: Restenosis after balloon injury consisted of arterial remodeling and neointimal hyperplasia, whereas that after stenting consisted mostly of neointimal hyperplasia. The neointimal area in the SG lasted longer than that in the BG. Continuous inflammation may be an important factor in the restenosis of stenting.


OBJECTIVES: The purpose of this study was to examine the effect of intracoronary radiation therapy (IRT) in diabetic patients with in-stent restenosis (ISR). BACKGROUND: Diabetic patients are at an increased risk for restenosis, repeat revascularization procedures and late mortality after percutaneous coronary interventions and stenting. Intracoronary radiation therapy, utilizing both gamma and beta-emitters, has been shown to reduce the rate of ISR. METHODS: The study group consisted of 749 consecutive patients with ISR who were treated with either IRT or placebo in randomized trials and registries at our center. Diabetic patients (252 radiation and 51 placebo) were compared with nondiabetic patients (371 radiation and 75 placebo). RESULTS: In-hospital outcomes were similar between diabetic and nondiabetic patients treated with and without radiation. At six-month clinical and angiographic follow-up, there was a significant reduction in the binary restenosis (63.8% vs. 15.7%, p < 0.0001), target lesion revascularization (66.7% vs. 17.6%, p < 0.0001) and target vessel revascularization (TVR) (70.6% vs. 22.9%, p < 0.0001) rates in diabetic patients treated with radiation compared to placebo. Comparisons between the placebo arms detected a trend towards higher restenosis (63.8% vs. 48.4% p = 0.13) and TVR (70.6% vs. 56.0%, p = 0.14) in diabetic versus nondiabetic patients. In contrast, diabetic and nondiabetic patients treated with IRT experienced similar restenosis (15.6% vs. 10.7% p = 0.33) and TVR (22.9% vs. 28.2% p = 0.41) rates. CONCLUSIONS: In diabetic patients with ISR, intracoronary radiation significantly reduced the recurrence of ISR compared to placebo. Additionally, similar rates of restenosis and revascularization procedures were achieved in irradiated diabetic and nondiabetic patients. In view of these results, IRT should be considered as a valuable therapeutic alternative in all diabetic patients with ISR.


Intracoronary beta (beta) radiation decreases the incidence of target lesion revascularization after percutaneous intervention (PCI) for in-stent restenosis (ISR). Cutting balloon (CB) angioplasty may also be superior to other percutaneous techniques for the treatment of ISR. We sought to study the outcomes of patients with ISR who underwent both CB angioplasty and intracoronary beta radiation and compare them to patients with ISR who underwent other PCI techniques without concomitant radiation. We also sought to evaluate the safety and efficacy of pullback intracoronary beta radiation for the treatment of long ISR lesions. Between January 2001 and November 2001, 102 patients (mean age = 55 ± 13 years) with ISR underwent both CB angioplasty and intracoronary beta radiation. Beta radiation was delivered using the Beta Cath (Novoste) 30 mm system, and pullback radiation was performed in 41 patients. A comparison group included a total of 393 patients with ISR who underwent other PCI techniques without concomitant intracoronary radiation therapy. Follow-up was obtained in 99 patients (97%) in the CB angioplasty with intracoronary radiation group and 377 patients (96%) in the comparison group. At follow-up, both target vessel revascularization (TVR) and major adverse cardiovascular events (MACE) occurred significantly less in the CB angioplasty with intracoronary radiation group than in the comparison group (7% vs. 18% for TVR, and 14% vs. 24% for MACE; P < 0.05 for both). In the pullback radiation group, TVR was performed in five patients (12%), and MACE occurred in eight patients (20%). A combination of CB angioplasty and intracoronary beta radiation for ISR seems to yield low rates of subsequent target vessel revascularization and adverse cardiac events. In addition, pullback beta radiation using the Beta Cath (Novoste) 30 mm system is safe and can be used to treat long ISR lesions effectively. Further randomized trials are needed to confirm these findings. Copyright 2002 Wiley-Liss, Inc.
Clinical outcomes of patients treated with the cutting balloon and Sr−90 beta−irradiation for instent restenosis.


BACKGROUND: The cutting balloon (CB) is an emerging therapy for the treatment of instent restenosis (ISR), but its impact on the clinical outcomes of patients treated with intracoronary radiation therapy (IRT) with Sr−90 compared with conventional PTCA and IRT is not clearly defined. METHODS: We compared the baseline demographics, angiographic characteristics and clinical outcomes of 102 consecutive patients with ISR treated either with CB (n=45) or with conventional PTCA (n=57). The combined endpoint was the occurrence of major adverse cardiac events (MACE), which was defined as a composite of death, myocardial infarction (MI) or target vessel revascularization (TVR) at 6 months. RESULTS: The CB group had a shorter mean lesion length (14.36.5 vs. 21.115.7, P=.009), and greater utilization of glycoprotein IIb/IIIa inhibitors during the procedure (48.9% vs. 26.3%, P=.02) compared to the PTCA group. There were no significant differences in the baseline demographics, angiographic and procedural results, or subsequent MACE at 6 months between the two groups. CONCLUSION: The strategy of CB using Sr−90 for ISR is associated with similar procedural and clinical outcomes compared to conventional PTCA. Further study is warranted to determine which patient subgroups would derive the most benefit from this approach.
Elderly patients have a favorable outcome after intracoronary radiation for in-stent restenosis.

Ajani AE, Waksman R, Cheneau E, Cha DH, Pinnow E, Pichard AD, Satler LF, Kent KM, Lindsay J.

Intracoronary radiation therapy (IRT) reduces recurrent in-stent restenosis (ISR) by inhibition of smooth muscle cell proliferation. The ability of these cells to replicate is limited with age due to changes in the telomeres. The purpose of this study was to assess the effect of age on outcomes following IRT for ISR. We evaluated 1,088 patients with 6-month clinical follow-up who were enrolled in radiation trials for ISR using gamma- and beta-emitters. Patients were analyzed within and between IRT (n = 861) or placebo therapy (n = 227) in four age groups (< 55, 55–65, 66–75, > 75 years). Baseline characteristics were similar within each age group of IRT patients, except elderly patients (> 75 years) had a lower rate of diabetes (28% in patients > 75 years; P = 0.008) and a higher rate of previous CABG (59% in patients > 75 years; P < 0.001). The rate of target lesion revascularization (TLR) was reduced in the elderly. TLR at 6 months was 18% in patients < 55 years, 21% in 55–65 years, 12% in 66–75 years, and 10% in patients > 75 (P = 0.009). The MACE rate at 6 months was 21% in patients < 55 years, 29% in 55–65 years, 26% in 66–75 years, and 17% in patients > 75 (P = 0.03). No effect of age was seen in placebo patients. IRT-treated patients had reduced MACE compared to placebo in all age groups, driven by reduced target vessel revascularization. Age was an independent predictor of MACE at 6 months (OR = 0.8; CI = 0.70–0.93; P = 0.004). Angiographic restenosis was not clearly associated with need for TLR in patients > 75 years. In elderly patients (> 75 years) treated with IRT for ISR, the rate of TLR was significantly reduced compared to younger patients. However, this reduction in TLR was not associated with a reduction in angiographic restenosis, suggesting that TLR should not be used as a surrogate for angiographic evaluation.


Catheter-based intracoronary radiation therapy demonstrated reduction of the recurrence rate of in-stent restenosis by 35%-50% when compared to conventional therapy. The objectives of this study were to determine the safety and feasibility of a new balloon-shaped source design and a higher applied dose to reduce the restenosis rates. Thirty-two patients with in-stent restenosis who met study eligibility criteria were successfully treated with standard PCI techniques. Following a successful intervention, a P-32 beta-balloon source was positioned to cover the angioplasty site and a dose of a 20 Gy at 1 mm from the surface of the source was administered. The primary endpoint was a composite of major adverse cardiac events (any death, MI, emergent CABG, or repeat target vessel revascularization) during 6 months of follow-up. At 6 months, only one patient underwent repeat PTCA to the target vessel (3%). There were no instances of death, emergency surgery, late thrombosis, total occlusions, or MI. Binary restenosis measured by QCA at the stented segment was 0% and for the whole analysis vessel was 7.5%. Beta-radiation delivered with a balloon P-32 source design for patients with in-stent restenosis results in lower than expected rate of angiographic and clinical restenosis and the absence of late complications. Copyright 2002 Wiley-Liss, Inc.
Long-term outcome of patients treated with repeat percutaneous coronary intervention after failure of gamma-brachytherapy for the treatment of in-stent restenosis.


BACKGROUND: Although (192)Ir intracoronary brachytherapy has been demonstrated to dramatically reduce the recurrence of in-stent restenosis, up to 24% of these patients will still require repeat target-vessel revascularization. The short- and long-term outcomes of repeat percutaneous intervention in this population have not been characterized. METHODS AND RESULTS: Analysis was performed of all patients enrolled in the GAMMA-I and GAMMA-II brachytherapy trials who underwent repeat percutaneous target lesion revascularization (TLR) because of restenosis. Subjects were divided into 2 cohorts: those who had received (192)Ir brachytherapy and those randomized to placebo. Forty-five (17.6%) of a total of 256 patients whose index treatment was intracoronary radiation therapy and 36 (29.8%) of 121 patients whose index treatment was placebo required repeat percutaneous TLR. The mean time to this first TLR was 295206 days in the irradiated group and 202167 days in the placebo group (P=0.03). Acute procedural success occurred in 100% of irradiated patients and 94% of placebo controls (P=0.19). After the first TLR, a subsequent TLR was required in 15 (33.3%) of 45 brachytherapy patients versus 17 (47.2%) of 36 placebo failure patients (P=0.26). There was no significant difference in time to second TLR between the 2 groups. Other long-term major adverse event rates in both groups were comparable to those of other contemporary angioplasty/stenting series. CONCLUSIONS: In those patients who "fail" (192)Ir intracoronary brachytherapy for in-stent restenosis, treatment with (192)Ir delays the time to first TLR. Additionally, repeat percutaneous intervention in these patients is safe and efficacious in the short term, with acceptable long-term results.
Device selection in the treatment of in-stent restenosis with and without radiation (from the Gamma Radiation Trials).


In-stent restenosis (ISR) is a major limitation of coronary stenting and is associated with high recurrence rates after intervention with all available devices. Intracoronary gamma (gamma) radiation was proved to reduce the recurrence rate after conventional therapy. The purpose of this study was to compare the different devices utilized for the treatment of ISR with and without gamma radiation. To search for the optimal device for the treatment of ISR, 685 patients from the radiation trials for ISR who were randomized to either iridium-192 gamma radiation (559 patients) or placebo (126 patients) following intervention were evaluated. Devices used included balloon percutaneous transluminal coronary angioplasty, excimer laser coronary angioplasty (ELCA), rotational atherectomy, and additional stent implantation. Baseline clinical and angiographic characteristics were similar between the gamma radiation and placebo groups. One- and 6-month clinical and angiographic outcomes were compared. The use of stenting compared with other devices was associated with increased late loss. Device selection used as adjunctive therapy did not influence the 30-day outcome. Patients treated with gamma radiation and placebo therapy had similar rates of composite major adverse coronary events (MACE) (death, Q-wave myocardial infarction, target vessel revascularization) (3% vs 2%, p = NS). At 6 months, MACE rates in irradiated patients were similar among POBA (29%), ELCA (28%), rotational atherectomy (18%), and additional stent implantation (30%, p = NS), and were significantly lower compared with placebo for the entire cohort and for each device subgroup. The overall recurrence rate of ISR was lower in patients treated with gamma radiation using iridium-192 compared with placebo. Device selection did not influence late clinical outcomes in irradiated and nonirradiated groups.
Comparison of the morphological changes of restenosis after the implantation of various types of stents in a swine model.

Yorozuya M, Suzuki H, Iso Y, Shibata M, Nakatani M, Koba S, Murakami M, Katagiri T, Takeyama Y.

BACKGROUND: Stent design causes the differences of restenosis rate, but the morphological differences after the various types of stent implantation have not been clarified. DESIGN: Seven types of stents were implanted in pig coronary arteries to clarify how the mechanism of restenosis differs with coil stents and tube stents. METHODS: The left anterior descending coronary arteries (LADs) of pigs were injured using coronary angioplasty balloons (diameter: 3.0 mm; length: 20 mm; balloon/artery ratio: 1 : 2). Fourteen days after the injury, four types of coil stents (Cordis, Wiktor, GR-I, and GR-II) and three types of tube stents (Palmaz–Schatz, gfx, and Multilink) were implanted, and the LADs were extracted 28 days after the implantation. RESULTS The proliferated neointima was eccentric in the coil stents and concentric in the tube stents. Although there was no significant difference in the area of neointima, the area of the lumen was significantly larger in the tube stents than in the coil stents ( < 0.01) because of the larger area of stent. Cells positive for anti-proliferating cell nuclear antigen antibody were mainly observed around the stent struts, and most of these cells were also positive for either anti-macrophage or anti-smooth muscle actin antibodies. CONCLUSIONS Compared to the coil stents, the tube stents induce less negative remodelling including stent recoil, resulting in a wider luminal area. In order to prevent restenosis, it is crucial to implant a stent that will cause less negative remodelling.
Patterns of in-stent restenosis after placement of NIR gold-coated stents in unselected patients.

Danzi GB, Capuano C, Sesana M, Di Blasi A, Predolini S, Antoniucci D.

The aim of this study was to assess the incidence and angiographic patterns of in-stent restenosis 6 months after the implantation of NIR gold-coated stents in an unselected patient population. One hundred and sixteen consecutive patients were treated with the implantation of 149 NIR gold-coated stents. The majority of the patients (52%) had unstable angina or acute myocardial infarction. The baseline lesion morphology was complex in 78% of cases: the mean lesion length was 18 ± 5 mm. The procedural success rate was 97%. Subacute stent thrombosis occurred in three patients (2.6%). During the 6-month follow-up, there were 2 deaths and 22 subjects (19.5%) underwent target vessel revascularization. The 6-month event-free survival was 60%. The angiographic restenosis rate was 32%. In 83% of the cases, the morphology of the restenosis was proliferative; in the remaining 17%, it presented as total occlusion. In conclusion, the restenosis rate after NIR gold-coated stent implantation in high-risk patients is similar to that reported using other stent designs. However, restenosis was always diffuse, involving the overall stent length and extending beyond the margins, thus indicating a greater proliferative neointimal response to this device.
Results of Prevention of RESTenosis with Tranilast and its Outcomes (PRESTO) trial.


BACKGROUND: Restenosis after percutaneous coronary intervention (PCI) is a major problem affecting 15% to 30% of patients after stent placement. No oral agent has shown a beneficial effect on restenosis or on associated major adverse cardiovascular events. In limited trials, the oral agent tranilast has been shown to decrease the frequency of angiographic restenosis after PCI. METHODS AND RESULTS: In this double-blind, randomized, placebo-controlled trial of tranilast (300 and 450 mg BID for 1 or 3 months), 11,484 patients were enrolled. Enrollment and drug were initiated within 4 hours after successful PCI of at least 1 vessel. The primary end point was the first occurrence of death, myocardial infarction, or ischemia-driven target vessel revascularization within 9 months and was 15.8% in the placebo group and 15.5% to 16.1% in the tranilast groups (P=0.77 to 0.81). Myocardial infarction was the only component of major adverse cardiovascular events to show some evidence of a reduction with tranilast (450 mg BID for 3 months): 1.1% versus 1.8% with placebo (P=0.061 for intent-to-treat population). The primary reason for not completing treatment was > or =1 hepatic laboratory test abnormality (11.4% versus 0.2% with placebo, P<0.01). In the angiographic substudy composed of 2018 patients, minimal lumen diameter (MLD) was measured by quantitative coronary angiography. At follow-up, MLD was 1.76±0.77 mm in the placebo group, which was not different from MLD in the tranilast groups (1.72 to 1.78±0.76 to 80 mm, P=0.49 to 0.89). In a subset of these patients (n=1107), intravascular ultrasound was performed at follow-up. Plaque volume was not different between the placebo and tranilast groups (39.3 versus 37.5 to 46.1 mm³, respectively; P=0.16 to 0.72). CONCLUSIONS: Tranilast does not improve the quantitative measures of restenosis (angiographic and intravascular ultrasound) or its clinical sequelae.
Elective stenting in small coronary arteries: results of the Italian prospective multicenter registry MICROSCOPE.


BACKGROUND: The role of stent implantation in small coronary arteries is still controversial. The MICROSCOPE study (Ministenting in small coronary arteries, a prospective evaluation) is a multicenter registry addressed to prospectively evaluate the immediate and mid-term clinical and angiographic results of elective stenting of lesions located in coronary arteries with an angiographic reference diameter < or = 2.75 mm. METHODS: A total of 146 patients (160 lesions) were included in the study. The percentage of complex lesions (B2 and C lesions) was 49.3%. The clinical indications for stent implantation were: stable angina (55.0%), unstable angina (24.6%), and clinical evidence of myocardial ischemia in asymptomatic patients (20.4%); 60% of patients had multivessel disease. Stent deployment could be performed in 96.2% of lesions. The baseline reference diameter was 2.12 +/- 0.36 mm. In all cases the Ministent (Cordis, a J&J Company, Miami, FL, USA), specifically designed for small coronary arteries, was employed. The stent was pre-mounted on low profile balloons available in three different diameters (2.25, 2.50 and 2.75 mm) and three different lengths (11, 15 e 26 mm). RESULTS: The primary endpoint of successful stent-assisted angioplasty in all study vessels without major adverse cardiac events was achieved in 95.8% of the patients. The minimal lumen diameter increased from 0.64 +/- 0.24 to 2.02 +/- 0.43 mm and the dimensions of the stenosis (expressed as a percentage of the diameter of the coronary vessel) decreased from 68.6 +/- 10.8 to 16.2 +/- 10.7% (< 30% standard deviation in all cases). After the procedure all the patients received double antiplatelet therapy for 4 weeks. Post-procedural complications were limited to 2 patients (1.3%) who had a non-Q wave myocardial infarction at 6 months of follow-up; 13 patients (11%) required target lesion revascularization. No patient died following the procedure. Angiographic control was performed in 44% of lesions. The minimal lumen diameter decreased to 1.12 +/- 0.47 mm and the percent stenosis increased to 45.9 +/- 23.2%. The incidence of binary restenosis (stenosis > or = 50%) was 41%. CONCLUSIONS: Elective stenting of small coronary arteries with the Ministent can be safely performed and is associated with a low incidence of acute or subacute stent thrombosis. The mid-term results indicate a high rate of angiographic restenosis but a low need of target vessel revascularization. These data suggest that stenting cannot be considered the treatment of choice for unselected lesions located in coronary arteries with a small reference diameter, but represents a safe
solution if unsatisfactory results are obtained with balloon angioplasty alone.
Heparin–coated stent placement for the treatment of stenoses in small coronary arteries of symptomatic patients.


BACKGROUND: The role of stents, especially of heparin–coated stents for the treatment of stenoses in small coronary arteries, is still unclear. Therefore, we performed this prospective, randomized trial to evaluate the angiographic and clinical outcome after treatment of stenoses in small coronary arteries (2.0 to 2.6 mm) of symptomatic patients. METHODS AND RESULTS: We randomly assigned 588 patients to angioplasty (n=195), bare stenting (n=196), or heparin–coated stenting (n=197). The primary end point was minimal lumen diameter (MLD) at 6 months. With comparable baseline parameters, the two stent arms showed a larger postinterventional MLD, larger acute gain, and smaller residual percent diameter stenosis, although a residual stenosis of 12+/−16% was achieved in the angioplasty arm, including a 27% crossover rate to stenting. Eighty percent of patients had follow–up angiography, which documented a borderline significantly larger MLD and smaller percent diameter stenosis for the two stent groups (1.34+/−0.48 mm and 1.42+/−0.48 mm after angioplasty, 1.47+/−0.48 mm and 36+/−20% after bare stenting, and 1.45+/−0.54 mm and 38+/−23% after heparin–coated stenting; P=0.049 and P=0.038, respectively), but restenosis rates were not different (32%, 25%, and 30%). Thrombotic events occurred in 1.0% after angioplasty and 0.5% after bare or heparin–coated stenting. Survival without myocardial infarction or target vessel revascularization at 250 days was 84.6% (angioplasty), 88.3% (bare stenting), and 88.3% (heparin–coated stenting; log–rank P=0.39). CONCLUSION: Compared with angioplasty with provisional stenting, bare and heparin–coated stenting confer superior angiographic results and a nonsignificant 24% reduction in clinical events, with no difference between bare and heparin–coated stenting in the treatment of stenoses in small coronary arteries.
Effect of percutaneous coronary interventions for in-stent restenosis in degenerated saphenous vein grafts without distal embolic protection.


OBJECTIVES: This study was designed to investigate the impact of percutaneous coronary interventions (PCIs) in degenerated saphenous vein grafts (SVGs) without distal embolic protection. BACKGROUND: Distal embolic protection devices have been shown to reduce the incidence of no reflow/slow flow during PCI of de novo lesions in degenerated SVGs. It is unclear whether PCI of in-stent restenosis (ISR) lesions in degenerated SVGs is associated with no reflow/slow flow and whether distal embolic protection is beneficial in these cases as well. METHODS: We studied 54 consecutive patients with treated ISR lesions in degenerated SVGs who underwent PCI without distal embolic protection in a single center. Procedural and in-hospital outcomes were examined. The average age was 71 +/- 8 years; 32% of the patients had diabetes. The mean lesion length was 13 +/- 6 mm and the procedural success rate was 98% (53/54). Cutting balloon angioplasty was used in 46% (25/54) of cases, and a new stent was inserted in 46% (25/54) of patients. Gamma brachytherapy was performed in 19% (10/54) of patients. During the procedure there were no episodes of no reflow/slow flow, and there were no patients with in-hospital Q-wave or non-Q-wave myocardial infarction. There was one in-hospital noncardiac death. CONCLUSIONS: In this consecutive series of patients with ISR of degenerated SVGs undergoing PCI without distal protection, there were no episodes of slow flow/no reflow and no procedure-related myocardial infarctions. It appears that distal embolic protection may not be necessary during PCI of ISR lesions in degenerated SVGs.
Clinical impact of drug–eluting stents in changing referral practices for coronary surgical revascularization in a tertiary care center.

Ferreira AC, Peter AA, Salerno TA, Bolooki H, de Marchena E.

BACKGROUND: The long-term benefits of angioplasty are limited by the occurrence of restenosis. Drug–eluting stents with a projected restenosis rate of close to 0% are soon to become available. The short- and long-term consequences of this advance to the cardiac surgical volume remain unclear.

METHODS: A total of 196 consecutive coronary angiograms and medical records of patients referred for coronary bypass surgery were reviewed. Considering the hypothetical premise of having drug–eluting stents with a near zero restenosis rate, we reviewed each case to determine if surgical revascularization was still the preferred option for revascularization. RESULTS: The mean age was 60 (+/-10.6) years. Seventy-two percent of patients were male. Considering the availability of drug–eluting stents 154 (79%) would still have been sent to surgery, representing a 21% decrease in the number of surgical revascularizations. Angiographic characteristics predicting coronary bypass revascularization were the presence of chronic total occlusion (odds ratio [OR]: 9.1; confidence interval [CI]: 2.1 to 39), left main coronary artery stenosis (OR: 9.6; CI: 1.27 to 73), and need for valvular surgery (OR: 7.38; CI: 1.3 to 157). The most common predictors of a change in clinical management from surgical to percutaneous revascularization if drug–eluting stents were available were diffuse coronary narrowing (OR: 15.78), restenotic lesions (OR: 27.86), and small coronary arteries (OR: 26). CONCLUSIONS: Drug–eluting stents may have a significant impact on cardiac surgery volume (approximately a 21% decrease in our center). It may also direct patients with small vessels, diffuse narrowing, or restenotic lesions and diabetic patients to percutaneous therapy.
The outcome of percutaneous coronary intervention in patients with in-stent restenosis who failed intracoronary radiation therapy.

Ajani AE, Waksman R, Cheneau E, Cha DH, McGlynn S, Castagna M, Chan RC, Satler LF, Kent KM, Pichard AD, Pinnow E, Lindsay J.

OBJECTIVES: This study reports the outcome of patients who failed intracoronary radiation therapy (IRT) for the treatment of in-stent restenosis (ISR). BACKGROUND: Intracoronary radiation therapy has demonstrated a reduction in the recurrence rate of restenosis for patients with ISR. However, 10% to 30% of these patients require repeat intervention to the irradiated site. METHODS: Of 961 patients who were assigned to gamma or beta radiation for the treatment of diffuse ISR, we evaluated the outcome of 282 (29%) consecutive patients who failed IRT and compared them with the 679 (71%) patients who had successful IRT. For patients who failed radiation, the mean time to the first target vessel revascularization (TVR) was 173 +/- 127 days after the index procedure and the total duration of follow-up was 494 +/- 304 days. RESULTS: Patients who failed IRT were younger (60 +/- 10 vs. 63 +/- 11 years, p = 0.002) and had a higher incidence of restenting (51% vs. 41%, p = 0.003). The majority (55%) of the restenotic lesions after IRT failure were focal (< or =10 mm), with a mean lesion length of 11.9 +/- 1.9 mm. Of the 257 patients who had subsequent TVR after failed IRT, 68 (26%) underwent coronary artery bypass grafting and 189 (74%) underwent percutaneous coronary intervention using balloon in 61%, restenting in 26%, atheroablation in 11%, and the cutting balloon in 2% of cases. At six months, 6% of patients died, 1% had Q-wave MI, 17% had repeat TVR, and the overall rate of major adverse cardiac events was 21%. CONCLUSIONS: The predominant angiographic pattern of lesions in patients who failed IRT is focal restenosis, with these lesions responding well to conventional revascularization methods.
Low restenosis rate of the NIR coronary stent: results of the Danish multicenter stent study (DANSTENT)—a randomized trial comparing a first-generation stent with a second-generation stent.


BACKGROUND: Larger studies evaluating the angiographic results of second-generation stents are scarce. The objectives of this study were to assess current standards of angiographic and clinical outcomes after implantation of the second-generation stainless steel stent, NIR (Medinol Ltd, Tel Aviv, Israel), and to compare the outcomes with those of the first-generation Palmaz-Schatz (PS) stent (Johnson & Johnson, Warren, NJ). METHODS: Patients having coronary artery lesions that could be covered by a stent of 15 mm in length were randomly assigned to receive the NIR or the PS. Procedural success, 6-month angiographic findings, and 1-year clinical outcomes were determined. RESULTS: In 424 patients included in the study, the overall procedural success rate was high (NIR 98%, PS 99%, P = .90). Follow-up angiography was conducted in 91% of the patients. The overall rate of angiographic restenosis was low in both groups (NIR 9.9%, PS 12.6%, P = .35). We found a low restenosis rate in vessels with a minimal lumen diameter >3.1 mm after the procedure, particularly in the NIR group (<6%). The rate of target lesion revascularization after 1 year did not differ (NIR 12%, PS 10%, P = .47). CONCLUSIONS: The angiographic and clinical outcomes after implantation of the second-generation stainless steel stent were not significantly better than those of the first-generation stent. The low restenosis rates, particularly in patients with the largest minimal lumen diameters after stent implantation, warrants circumspection when planning the evaluation of newer stent technologies that aim to further reduce coronary restenosis.
Randomized comparison of mounted versus unmounted stents: the multicenter COMUS trial.


BACKGROUND: Although the use of premounted stents on a delivery balloon has almost completely eliminated the initially used hand-crimping procedure, no data are available that prove the superiority of one or the other approach on a randomized basis. Therefore, this study was designed to examine whether the use of premounted stents is comparable with the hand-crimping procedure. METHODS: A total of 123 patients (64 treated with unmounted stents, 59 treated with premounted stents) were examined in a multicenter, randomized, prospective study. There were no significant differences in patient characteristics between groups. RESULTS: Primary end points (acute, postinterventional [within 72 hours], and late complications related to the stenting procedure) were reached in 1 patient treated with an unmounted stent versus 2 patients with mounted stents (P = not significant). In patients with angiographic follow up (n = 84, mean follow-up period 6 +/- 1 months), the total rate of restenosis was 27% (unmounted 12, mounted 11, P = not significant). Secondary end points were procedural success of stenting and maximal balloon inflation pressure needed for optimal stenting results by use of angiography. There were no differences in secondary end points for both techniques. The mean balloon pressure was 12.56 +/- 2.1 atmospheres (unmounted) and 12.12 +/- 1.92 atmospheres (mounted, P = not significant). CONCLUSION: Stenting with premounted devices was demonstrated to have a similar clinical and angiographic outcome as the hand-crimping approach for maximal inflation pressure, procedural success, major cardiac events, and rate of restenosis after 6 months of follow up. Thus, the more convenient use of a premounted stent provides procedural safety and efficacy comparable with a hand-crimped system.
Endovascular brachytherapy to prevent restenosis after angioplasty

Wohlgemuth WA, Bohndorf K.

Endovascular radiotherapy is the first effective prophylaxis of restenosis after percutaneous transluminal angioplasty (PTA) and stenting. The FDA recently approved two devices for the delivery of intracoronary radiation following coronary artery stenting. Published multicenter, double-blind, randomized trials of intracoronary radiation therapy report good results for preventing in-stent restenosis, while the data for the peripheral circulation are still inconclusive. Beta-emitters are easier applicable and probably also safer, whereas gamma-emitters have been more extensively evaluated clinically so far. Primary indication for endovascular brachytherapy are patients at high risk for restenosis, such as previous restenoses, in-stent hyperplasia, long stented segment, long PTA lesion, narrow residual vascular lumen and diabetes. Data from coronary circulation suggest a safety margin of at least 4 to 10 mm at both ends of the angioplastic segment to avoid edge restenosis. To prevent late thrombosis of the treated coronary segment, antiplatelet therapy with clopidogrel and aspirin are recommended for at least 6 months after PTA and for 12 months after a newly implanted stent. An established medication regimen after radiotherapy of peripheral arteries is still lacking.
Postprocedure chest pain after coronary stenting: implications on clinical restenosis.

Kini AS, Lee P, Mitre CA, Duffy ME, Sharma SK.

OBJECTIVES: The goal of this study was to analyze the incidence and predictors of postprocedure chest pain (PPCP) after percutaneous coronary intervention (PCI) and its correlation with clinical restenosis. BACKGROUND: Chest pain after PCI occurs frequently even in the absence of procedural events and is considered to be due to vasospasm or coronary artery stretch. The short- and long-term significance of PPCP after otherwise successful stenting is not clear. METHODS: We analyzed 1,362 patients undergoing coronary stenting for PPCP, procedural and in-hospital events, 30-day major adverse cardiac events, and target vessel revascularization (TVR) at 6 to 9 months. RESULTS: There were 488 patients with PPCP and, of these, 312 patients were excluded due to procedural events. The remaining 176 patients with PPCP were compared with 874 patients without PPCP. Creatine kinase-MB isoenzyme elevation occurred in 25.6% of the PPCP group versus 9.6% of the no PPCP group (p < 0.001). Despite similar reference vessel diameter, the PPCP group had larger postprocedure minimum lumen diameter, higher stent-to-vessel ratio, and higher inflation pressure versus the no PPCP group (p < 0.01). At 30 days, the emergency room visits and repeat catheterization (16% vs. 2.7%; p < 0.001) were higher in the PPCP group versus the no PPCP group, but repeat intervention was similar. At 6- to 9-month follow-up, the TVR was significantly higher in the PPCP group compared with the no PPCP group (29.5% vs. 16.6%; p < 0.01). CONCLUSIONS: Our analysis suggests micromyonecrosis and vessel stretch as causes of PPCP. Postprocedure chest pain is associated with similar short-term outcome as no PPCP, but has higher restenosis, perhaps mediated by deep vessel wall injury. Therefore, PPCP may identify patients at high risk for restenosis.
Effect of angiotensin-converting enzyme inhibition on restenosis after coronary stenting.


The Plasma level of angiotensin-converting enzyme (ACE) has been identified as a major risk factor for restenosis after coronary stent implantation in selected patients: ACE inhibition may therefore contribute to prevent its occurrence. The effect of oral ACE inhibition at conventional doses was analyzed retrospectively in a series of 897 patients with ischemia who received \( \geq 1 \) coronary stent on 998 lesions and underwent angiographic follow-up; no exclusion criteria were introduced in this analysis. The restenosis rate in 282 patients (31.4%) taking ACE inhibitors was 36.6% compared with 22.9% in 615 non-ACE-inhibited patients (\( p = 0.00001 \), odds ratio [OR] 1.94, 95% confidence interval [CI] 1.45 to 2.59), and the late loss in minimum lumen diameter was 1.25 +/- 0.8 versus 0.96 +/- 0.8 mm, respectively (\( p = 0.0001 \)). During univariate analysis, a negative effect of the drug on restenosis was observed in all subgroups of patients (i.e., hypertensives, diabetics, women, and patients with previous myocardial infarction). Similar effects were observed independently of the ACE gene insertion/deletion polymorphism. During multivariate analysis, ACE inhibition was confirmed as an independent risk factor for restenosis (OR 1.84, 95% CI 1.35 to 2.51, \( p = 0.0001 \)). Other predictors were the implantation of multiple stents (OR 2.41, 95% CI 1.60 to 3.64, \( p < 0.0001 \)), diabetes (OR 2.34, 95% CI 1.61 to 3.41, \( p < 0.0001 \)), and vessel reference diameter before angioplasty (OR 0.51, 95% CI 0.38 to 0.69, \( p < 0.0001 \)). Although unexplained and apparently contradictory, our data suggest that the use of conventional oral doses of ACE inhibitors in a "real-world" population who underwent coronary stent implantation increases the incidence of in-stent restenosis. Such a finding does not negate the known clinical benefits of ACE inhibitors, but it may deserve attention when a patient treated with ACE inhibitors becomes a candidate for stent implantation.
Influence of residual stenosis after percutaneous coronary intervention with stent implantation on development of restenosis and stent thrombosis.


The aim of this study was to assess the effects of residual stenosis after single-stent implantation on the rate of stent thrombosis, as well as restenosis within a 6-month follow-up period. Coronary angiograms of 2,157 patients with 2,523 lesions treated with a single stent were analyzed by quantitative coronary angiography before, immediately after stent implantation, and at a planned 6-month follow-up. Lesions were classified into 4 subgroups according to the degree of residual stenosis after stent implantation: group 1, gross oversizing < -15%; group 2, slight oversizing -15% to < 0%; group 3, mild residual 0% to <15%; group 4, moderate residual 15% to <30%. Stent thrombosis rates were not significantly different among the 4 subgroups (group 1: 0 of 60 [0%]; group 2: 2 of 388 [0.5%]; group 3: 8 of 1,370 [0.6%]; group 4: 8 of 705 [1.1%]; p = NS for all). An adequate dosage of ticlopidine (250 mg twice daily) and aspirin (100 mg/day) led to a lower rate of stent thrombosis (6 of 2,189 cases) than inadequate dosages or missing therapy (12 of 343 cases). In 1,882 stenoses with angiographic follow-up (77.7%), gross oversizing of stents lead to a significantly higher increase of percent stenosis (p < 0.001) associated with a higher restenosis rate (group 1: 34.7% vs groups 2, 3, and 4: 32.5%, 28.2%, and 29.6%, respectively). A multiple regression analysis was performed. Optimal results with regard to stent thrombosis and restenosis were achieved with mild residual stenoses between 0% and 15% after stent implantation. Oversizing of stents is no longer necessary with an adequate dosage of ticlopidine and aspirin.
Intravascular ultrasound guidance improves angiographic and clinical outcome of stent implantation for long coronary artery stenoses: final results of a randomized comparison with angiographic guidance (TULIP Study).


BACKGROUND: Long coronary lesions treated with stents have a poor outcome. This study compared the 6-month outcome of stent implantation for long lesions in patients randomized to intravascular ultrasound (IVUS; n=73) or angiographic guidance (n=71). METHODS AND RESULTS: Stenoses >20 mm in length and a reference diameter that permitted a stent diameter ≥ 3 mm were eligible. Primary end points were 6-month minimal lumen diameter (MLD) and the combined end point of death, myocardial infarction, and target-lesion revascularization (TLR). Baseline clinical and angiographic data were comparable in both groups. At 6 months, MLD in the IVUS group (1.82 +/- 0.53 mm) was larger than in the angiography group (1.51 +/- 0.71 mm; P=0.042). TLR and combined end-point rates at 6 months were 4% (n=3) and 6% (n=4) in the IVUS group and 14% (n=10) and 20% (n=14) in the angiography group, respectively (P=0.037 for TLR and P=0.01 for combined events). Restenosis (>50% diameter stenosis) was found in 23% of the IVUS group and 45% of the angiography group (P=0.008). At 12 months, TLR and the combined end point occurred in 10% (n=7) and 12% (n=9) of the IVUS group and 23% (n=17) and 27% (n=19) of the angiography group (P=0.018 and P=0.026), respectively. CONCLUSIONS: Angiographic and clinical outcome up to 12 months after long stent placement guided by IVUS is superior to guidance by angiography.
Comparison of outcomes in women and men treated with coronary stent implantation.


Worse outcomes have been observed in women after PTCA. The present study was undertaken to compare clinical and angiographic results of coronary stenting among women and men. We retrospectively analyzed acute and 6-month results in a consecutive series of 940 men and 160 women undergoing coronary stent implantation between May 1992 and January 1998. Women were older (63 vs. 57 years; P = 0.001), more often hypertensive (46.9% vs. 31.4%; P < 0.001) and diabetic (13.2% vs. 8.3%; P = 0.05), and less often smokers than men (32.5% vs. 70.5%; P < 0.001). A previous history of Q-wave MI was less frequently present in women (28.2% vs. 40.2%; P = 0.003) who more often underwent coronary revascularization because of unstable angina (37.5% vs. 27.1%; P = 0.027). No difference was observed in coronary artery disease extension, lesion complexity, and stented vessel between the sexes. Bailout stenting was more frequently needed in women (28% vs. 17.8%; P = 0.001). No difference was observed in the number of stent implanted per vessel and per patient and average maximal inflation pressure used for stent postdilation. However, a smaller final balloon size was used in women. Procedural and clinical success was achieved in 94.4% and 92.5% of women and 96.7% and 94.5% of men (P = NS), respectively, without differences regarding in-hospital major adverse cardiac events. Bleeding complications occurred more often in women when anticoagulation was used (OR = 2.87; 95% CI = 1.38-5.74). At 6-month clinical follow-up, TLR was similar between the sexes and event-free survival was 75.5% in women and 81.5% in men (P = NS). Angiographic follow-up, performed in 71% of the patients, showed that restenosis was 64% higher in women (OR = 1.64; 95% CI = 1.02-2.61). Despite older age, higher incidence of comorbidities, and more unstable presentation, women treated with coronary stenting showed acute and mid-term clinical results similar to those observed in men. However, they were significantly more likely to develop angiographic restenosis.


BACKGROUND: Coronary stents have been used with increasing frequency and in increasingly complex coronary lesions for the treatment of symptomatic coronary artery disease. A new stainless steel coronary stent, the R Stent, has been designed to provide maximum flexibility for tracking and high radial strength post-deployment. AIMS: To assess the safety and feasibility of the R Stent in patients with coronary artery disease. Specific objectives were to assess the R Stent's deployment success, angiographic and procedural success (< 20% residual stenosis and TIMI 3 flow), safety (absence of complications), 30-day and six-month clinical follow-up. METHODS: Between April 1998 and January 1999, stent deployment was attempted in 36 lesions in 30 patients with stable (43%) or unstable (57%) angina pectoris and 29/36 of the lesions were anatomically complex. Treated lesions were in the LAD (n = 15), RCA (n = 13) or LCX (n = 8). RESULTS: Stent deployment was achieved in 97% with one crossing failure in a patient with a long, calcified, proximal LAD lesion. After the procedure, patients were scheduled for one- and six-month clinical follow-up. One patient experienced a non-Q-wave myocardial infarction in hospital. At one month, there were no additional complications. Only one patient experienced recurrence of angina (CCS class 2) within the 30 days. At six-month follow-up, one sudden death had occurred. Three (10%) patients had anginal complaints, one of them received target lesion repeat PTCA. All other patients (87%) were event- and angina-free. CONCLUSION: This first clinical experience with the R Stent shows acceptable feasibility and safety with good long-term clinical results.
Clinical and angiographic results with the Coroflex Coronary Stent System.

Kalmbach C, Rutsch W, Figulla HR.

This is the first prospective study investigating the safety and efficacy of the new Coroflex Coronary Stent System regarding the incidence of major adverse cardiac events and the angiographic results during 6-month follow-up. The balloon-expandable Coroflex Stent is composed of stainless steel 316L, designed as a "slotted tube" with a 0.04" (0.97 mm) low crossing profile and high flexibility. A metal coverage of 12% allows easy side branch access. Between September 1998 and December 1998 five centers enrolled 113 patients with stable or unstable angina and a single de novo lesion in vessel sizes ≥ 2.75 mm. Procedural success was achieved in all 113 (100%) patients. During hospital stay one (0.88%) patient sustained a non-Q-wave myocardial infarction. Three patients died of a noncardiac reason during the 6-month follow-up. Quantitative coronary angiography (QCA) showed a minimal luminal diameter prior to intervention of 0.78 +/- 0.32 mm after PTCA 2.77 +/- 0.43 mm, and after 6 months a decrease to 2.06 +/- 0.76 mm, resulting in a loss index of 0.29 +/- 0.52 and a restenosis rate of 15.6% by QCA (n = 64) and 12.0% by visual estimation of additional 19 patients not suitable for QCA. The results of the Coroflex study demonstrated a low incidence of clinical events and complications and was combined with a low loss index and restenosis rate.
The extent of late in-stent neointima formation is modified by treatment with pravastatin: a preliminary study with intravascular ultrasound.


BACKGROUND: The aim of the present comparative, non-randomized intravascular ultrasound (IVUS) study was to test the effect of pravastatin on late neointima formation in stented de novo lesions. METHODS: The treatment group consisted of 28 consecutive patients in whom 31 stents were deployed; all patients were prescribed 40 mg daily of pravastatin for a mean follow-up period of 14 +/- 3 months (group 1). The control group consisted of 27 consecutive patients in whom 30 stents were deployed; lipid-lowering treatment was not prescribed; the mean follow-up period for this group of patients was 13 +/- 3 months (group 2). At follow-up IVUS images were acquired at a continuous 0.5 mm/s speed. IVUS measurements of the lumen area, stent area and neointima area were calculated within the stent at 0.5 mm intervals. RESULTS: The stent dimensions and technique of implantation were similar in the two groups. At follow-up the minimal lumen diameter at quantitative coronary angiography was slightly larger in group 1 than in group 2 (2.43 +/- 0.58 vs 2.17 +/- 0.59 mm, p = NS), while the late loss tended to be lower in group 1 than in group 2 (0.28 +/- 0.39 vs 0.63 +/- 0.37 mm, p = NS). At IVUS evaluation, the lumen and stent areas were similar in the two groups whereas the percent neointima area was significantly lower in group 1 than in group 2 (21 +/- 11 vs 29 +/- 11% respectively, p < 0.03). CONCLUSIONS: Pravastatin treatment was associated with a significantly reduced late in-stent neointima formation as assessed at IVUS.
Long-term outcome of patients treated with repeat percutaneous coronary intervention after failure of gamma-brachytherapy for the treatment of in-stent restenosis.


BACKGROUND: Although (192)Ir intracoronary brachytherapy has been demonstrated to dramatically reduce the recurrence of in-stent restenosis, up to 24% of these patients will still require repeat target-vessel revascularization. The short- and long-term outcomes of repeat percutaneous intervention in this population have not been characterized. METHODS AND RESULTS: Analysis was performed of all patients enrolled in the GAMMA-I and GAMMA-II brachytherapy trials who underwent repeat percutaneous target lesion revascularization (TLR) because of restenosis. Subjects were divided into 2 cohorts: those who had received (192)Ir brachytherapy and those randomized to placebo. Forty-five (17.6%) of a total of 256 patients whose index treatment was intracoronary radiation therapy and 36 (29.8%) of 121 patients whose index treatment was placebo required repeat percutaneous TLR. The mean time to this first TLR was 295+/−206 days in the irradiated group and 202+/−167 days in the placebo group (P=0.03). Acute procedural success occurred in 100% of irradiated patients and 94% of placebo controls (P=0.19). After the first TLR, a subsequent TLR was required in 15 (33.3%) of 45 brachytherapy patients versus 17 (47.2%) of 36 placebo failure patients (P=0.26). There was no significant difference in time to second TLR between the 2 groups. Other long-term major adverse event rates in both groups were comparable to those of other contemporary angioplasty/stenting series. CONCLUSIONS: In those patients who "fail" (192)Ir intracoronary brachytherapy for in-stent restenosis, treatment with (192)Ir delays the time to first TLR. Additionally, repeat percutaneous intervention in these patients is safe and efficacious in the short term, with acceptable long-term results.
Drug-eluting stent: the "magic bullet" for prevention of restenosis?

Hehrlein C, Arab A, Bode C.

The need for repeat interventions after initially successful PTCA due to restenosis has been called the "Archilles hee" of a percutaneous revascularization procedure. The incidence of restenosis varies between 20–50 % depending on the stent material, the presence of risk factors, and the location of vascular disease. Some risk factors such as diabetes have been clearly identified, others are currently debated. After years of failures trying to reduce restenosis rates, locally administered antiproliferative means have been shown to successfully inhibit excessive cell growth in response to PTCA. Local radiotherapy of in-stent restenosis results in a reduction of recurrent stenosis versus a conventional PTCA procedure. However, long-term evaluation indicated that restenosis may only be delayed with radiation therapy. Moreover, the restenosis rates were reduced, but the restenotic process was not eliminated. Coronary stents eluting the anti-proliferative agent rapamycin have demonstrated for the first time, that restenosis rates of zero percent are achievable after percutaneous revascularization procedures. Thus, it is intriguing to believe that the elimination of restenosis may have become reality. The purpose of this review is to discuss, whether a stent eluting drugs should be considered as the "magic bullet" for prevention of restenosis after PTCA.
Angiographic findings of the multicenter Randomized Study With the Sirolimus–Eluting Bx Velocity Balloon–Expandable Stent (RAVEL): sirolimus–eluting stents inhibit restenosis irrespective of the vessel size.


BACKGROUND: Restenosis remains the major limitation of coronary catheter-based intervention. In small vessels, the amount of neointimal tissue is disproportionately greater than the vessel caliber, resulting in higher restenosis rates. In the Randomized Study With the Sirolimus–Eluting Bx Velocity Balloon–Expandable Stent (RAVEL) trial, approximately 40% of the vessels were small (<2.5 mm). The present study evaluates the relationship between angiographic outcome and vessel diameter for sirolimus–eluting stents. METHODS AND RESULTS: Patients were randomized to receive either an 18-mm bare metal Bx VELOCITY (BS group, n=118), or a sirolimus–eluting Bx VELOCITY stent (SES group, n=120). Subgroups were stratified into tertiles according to their reference diameter (RD; stratum I, RD <2.36 mm; stratum II, RD 2.36 mm to 2.84 mm; stratum III, RD >2.84 mm). At 6-month follow-up, the restenosis rate in the SES group was 0% in all strata (versus 35%, 26%, and 20%, respectively, in the BS group). In-stent late loss was 0.01+/−0.25 versus 0.80+/−0.43 mm in stratum I, 0.01+/−0.38 versus 0.88+/−0.57 mm in stratum II, and −0.06+/−0.35 versus 0.74+/−0.57 mm in stratum III (SES versus BS). In SES, the minimal lumen diameter (MLD) remained unchanged (Δ = 0.72 to 0.72 mm) in 97% of the lesions and increased (=late gain, ΔMLD <−0.72 mm) in 3% of the lesions. Multivariate predictors for late loss were treatment allocation (P<0.001) and postprocedural MLD (P= 0.008). CONCLUSIONS: Sirolimus–eluting stents prevent neointimal proliferation and late lumen loss irrespective of the vessel diameter. The classic inverse relationship between vessel diameter and restenosis rate was seen in the bare stent group but not in the sirolimus–eluting stent group.
Predictive factors for early cardiac events and angiographic restenosis after coronary stent placement in small coronary arteries.


OBJECTIVES: The rationale of this study was to identify risk factors that predict early thrombotic events and angiographic restenosis after stenting in small coronary arteries. BACKGROUND: Rates of cardiac complications and restenosis after percutaneous coronary intervention are higher in patients with small versus large coronary arteries. Because of discordant results, randomized studies comparing stent placement with balloon angioplasty could not establish the best interventional approach to use in this high-risk subset of patients. This study of predictive factors, with special focus on stent design, may provide particular help in this regard. METHODS: Clinical, lesion-related, and procedural data of a large and unselected population of 3,156 consecutive patients were analyzed in a logistic regression model for both early and late complications. Repeat angiography at six months was performed in 80.8% of eligible patients. RESULTS: The strongest risk factors for early thrombotic events (cumulative incidence of 4.2%) were the presence of an acute coronary syndrome and reduced left ventricular function. The stent design had no influence on early thrombotic complications. Restenosis (overall rate of 38.4%) was predominantly influenced by procedure-related variables, including the stent design and stented segment length. The incidence of restenosis varied from 29.6% to 55.8%, depending on the stent design used. CONCLUSIONS: Clinical factors known before the procedure are predominant risk factors for early thrombotic complications, underscoring the need for potent antiplatelet regimens in these patients. In contrast, our findings suggest a major impact of procedural factors, including the choice of stent type, on restenosis.
Randomized comparison of success and adverse event rates and cost effectiveness of one long versus two short stents for treatment of long coronary narrowings.


Long stents of high flexibility and low profile have become widely available. Treatment of long coronary lesions by 1 long stent may require less interventional efforts and reduce the rate of restenosis due to a lack of overlapping stent segments. This study sought to evaluate the use of 1 long stent compared with 2 short stents for treatment of long coronary lesions. One-hundred twenty-four patients with a coronary lesion 20 to 40 mm in length, in a vessel 2.5 to 4.0 mm in diameter, were randomly assigned to treatment with 1 long stent (GFX II stents or S670 of 24, 30, or 40 mm lengths; n = 62) or 2 stents (GFX II or S670 stents, n = 62) of equal length. Procedural success, interventional costs, as well as long-term clinical and angiographic outcomes were evaluated. Lesion characteristics were similar for the 2 treatment groups. Stent placement was possible as assigned by randomization in 61 of 62 cases (98%) in the 1-long-stent group and 100% of cases in the 2-short-stents group. There was crossover to successful short-stent placement in 1 case. The in-hospital success rate was 97% for the 1-long-stent group and 98% for the 2-short-stents group. Acute angiographic results were similar for both groups after intervention. The angiographic restenosis rate at 6 months was 38.5% in the 1-long-stent group and 37.5% in the 2-short-stents group (p = 0.919). Intervention time was less, and the need for a contrast agent had a tendency to be lower in the long-stent group. Procedural costs were significantly less in the long-stent group. In conclusion, 1 long stent can be used with identical procedural success and adverse event rates as 2 short stents in long, atherosclerotic coronary lesions. The restenosis rate is not reduced by the use of 1 long stent compared with 2 stents. However, long stent placement is highly cost effective.
Predictive value of preprocedural fibrinogen concerning coronary stenting.

Otsuka M, Hayashi Y, Ueda H, Imazu M, Kohno N.

Elevated fibrinogen levels after coronary balloon angioplasty have been reported to be useful in predicting restenosis. Therefore, we sought to evaluate the relationship between preprocedural fibrinogen levels and the 6-12-month outcomes of patients undergoing coronary stenting. Plasma levels of fibrinogen were measured in 390 consecutive patients prior to coronary stenting. The primary end point was binary restenosis (percent diameter stenosis of \( \geq 50\% \)). The secondary combined end point was death due to cardiac causes, myocardial infarction related to the target vessel and target lesion revascularization. Patients were grouped into tertiles according to fibrinogen levels. Both at baseline and immediately after procedure, clinical and angiographic characteristics were almost identical in the fibrinogen tertiles. An increase in restenosis rate was observed across the tertiles (18.6, 23.9, 38.1\%, \( P<0.001 \), respectively). In addition, the frequency of the secondary end point increased in the highest tertile (14.9, 21.5, 37.2\%, \( P<0.001 \), respectively). Multivariate analysis revealed that high levels of fibrinogen (per 100 mg/dl, OR 1.82, \( P<0.001 \)) and stent length (\( P=0.034 \)) were independent predictors for restenosis. An elevated preprocedural fibrinogen level should be considered as a stronger predictor for restenosis after coronary stenting, which might be associated with coagulation and inflammation.
Comparison of stenting with minimally invasive bypass surgery for stenosis of the left anterior descending coronary artery.


BACKGROUND: Minimally invasive bypass surgery and coronary-artery stenting are both accepted treatments for isolated stenosis of the proximal left anterior descending coronary artery. We compared the clinical outcomes after these two procedures. METHODS: A total of 220 symptomatic patients with high-grade lesions in the proximal left anterior descending coronary artery were randomly assigned to treatment—110 to surgery and 110 to stenting. The combined clinical end point was freedom from major adverse cardiac events, such as death from cardiac causes, myocardial infarction, and the need for repeated revascularization of the target lesion within six months. RESULTS: A major adverse cardiac event occurred in 31 percent of patients after stenting, as compared with 15 percent in the surgery group (P=0.02). The difference was predominantly due to a higher rate of repeated revascularization of the target vessel for restenosis after stenting (29 percent vs. 8 percent, P=0.003). The combined rates of death and myocardial infarction did not differ significantly between groups (3 percent in the stenting group and 6 percent in the surgery group, P=0.50). Adverse events occurred more frequently after surgery. The percentage of patients free from angina after six months was 79 percent in the surgery group, as compared with 62 percent in the stenting group (P=0.03). CONCLUSIONS: In patients with isolated high-grade lesions of the proximal left anterior descending artery, both minimally invasive bypass surgery and stenting are effective. Stenting yields excellent short-term results with fewer periprocedural adverse events, but surgery is superior with regard to the need for repeated intervention in the target vessel and freedom from angina at six months of follow-up.
STENT RESTENOSIS

1. The outcome of percutaneous coronary intervention in patients with in-Stent restenosis who failed intracoronary radiation therapy.
Ajani AE, Waksman R, Cheneau E, Cha DH, McGlynn S, Castagna M, Chan RC, Satler LF, Kent KM, Pichard AD, Pinnow E, Lindsay J.
J Am Coll Cardiol 2003 Feb 19;41(4):551-6

Nakatani M, Takeyama Y, Shibata M, Yorozuya M, Suzuki H, Koba S, Katagiri T.
Cardiovasc Pathol 2003 Jan-Feb;12(1):40-8

J Am Coll Cardiol 2002 Jun 19;39(12):1930-6

Catheter Cardiovasc Interv 2002 Nov;57(3):325-9

5. Clinical outcomes of patients treated with the cutting balloon and Sr-90 beta-irradiation for instent restenosis.

6. Elderly patients have a favorable outcome after intracoronary radiation for in-stent restenosis.
Ajani AE, Waksman R, Cheneau E, Cha DH, Pinnow E, Pichard AD, Satler LF, Kent KM, Lindsay J.


10. Comparison of the morphological changes of restenosis after the implantation of various types of stents in a swine model.


12. Results of Prevention of RESTenosis with Tranilast and its Outcomes (PRESTO) trial.

13. Elective stenting in small coronary arteries: results of the Italian prospective multicenter registry MICROSCOPE.


18. Low restenosis rate of the NIR coronary stent: results of the Danish multicenter stent study (DANSTENT)–a randomized trial comparing a first-generation stent with a second-generation stent.


20. Endovascular brachytherapy to prevent restenosis after angioplasty


22. Effect of angiotensin-converting enzyme inhibition on restenosis after coronary stenting.

23. Influence of residual stenosis after percutaneous coronary intervention with stent implantation on development of restenosis and stent thrombosis.

24. Intravascular ultrasound guidance improves angiographic and clinical outcome of stent implantation for long coronary artery stenoses: final results of a randomized comparison with angiographic guidance (TULIP Study).

Int J Cardiovasc Intervent 2000 Jun;3(2):91-95

27. Clinical and angiographic results with the Coroflex Coronary Stent System.
Kalmbach C, Rutsch W, Figulla HR.

28. The extent of late in-stent neointima formation is modified by treatment with pravastatin: a preliminary study with intravascular ultrasound.
Ital Heart J 2002 Aug;3(8):455-61

Circulation 2002 Oct 29;106(18):2340-5

30. Drug-eluting stent: the "magic bullet" for prevention of restenosis?
Hehrlein C, Arab A, Bode C.
Basic Res Cardiol 2002 Oct;97(6):417-23

31. Angiographic findings of the multicenter Randomized Study With the Sirolimus-Eluting Bx Velocity Balloon-Expandable Stent (RAVEL): sirolimus-eluting stents inhibit restenosis irrespective of the vessel size.
Circulation 2002 Oct 8;106(15):1949-56

32. Predictive factors for early cardiac events and angiographic restenosis after coronary stent placement in small coronary arteries.
J Am Coll Cardiol 2002 Sep 4;40(5):882-9

33. Randomized comparison of success and adverse event rates and cost effectiveness of one long
versus two short stents for treatment of long coronary narrowings.
Am J Cardiol 2002 Sep 1;90(5):460-4

34. Predictive value of preprocedural fibrinogen concerning coronary stenting.
Otsuka M, Hayashi Y, Ueda H, Imazu M, Kohno N.
Atherosclerosis 2002 Oct;164(2):371-8

35. Comparison of stenting with minimally invasive bypass surgery for stenosis of the left anterior descending coronary artery.

J Am Coll Cardiol 2001 Mar 1;37(3):856-62

Coronary artery stenting in the aged.
Chauhan MS, Kuntz RE, Ho KL, Cohen DJ, Popma JJ, Carrozza JP Jr, Baim DS, Cutlip DE.

OBJECTIVES: The study compared the safety and efficacy of coronary artery stenting in aged and nonaged patients and identified predictors of adverse clinical outcomes. BACKGROUND: Limited data are available on the outcomes of stenting in the aged (> or = 80 years) compared to nonaged patients. METHODS: The study was a pooled analysis of 6,186 patients who underwent coronary artery stenting in six recent multicenter trials. A clinical events committee adjudicated clinical end points, and quantitative angiography was performed by an independent core laboratory. RESULTS: There were 301 (4.9%) aged patients (> or = 80 years). Compared to nonaged patients, aged patients had a higher prevalence of multivessel disease (16.5% vs. 9.6%, p = 0.001), unstable angina (50.8% vs. 42.1%, p = 0.003), moderate to severe target lesion calcification (30.4% vs. 15.3%, p = 0.001) and smaller reference vessel diameter (2.90 mm vs. 2.98 mm, p = 0.004). Procedural success rate (97.4% vs. 98.5%, p = 0.14) was similar in the two groups. In-hospital mortality (1.33% vs. 0.10%, p = 0.001), bleeding complications (4.98% vs. 1.00%, p <0.001) and one-year mortality (5.65% vs. 1.41%, p < 0.001) were significantly higher for the aged patients. Clinical restenosis was similar for the two groups (11.19% vs. 11.93%, p = 0.78). Advanced age, diabetes, prior myocardial infarction and presence of three-vessel disease were independent predictors of long-term mortality. CONCLUSIONS: Coronary artery stenting can be performed safely in patients > or = 80 years of age, with excellent acute results and a low rate of clinical restenosis, albeit with higher incidences of in-hospital and long-term mortality, and vascular and bleeding complications compared to
OBJECTIVES: This study assessed the predictive value of preprocedural C-reactive protein (CRP) levels on six-month clinical and angiographic outcome in patients undergoing coronary stent implantation.

BACKGROUND: Recent data indicate that low-grade inflammation as detected by elevated CRP serum levels predicts the risk of recurrent coronary events. METHODS: We prospectively investigated the predictive value of preprocedural CRP levels on restenosis and six-month clinical outcome in 276 patients after coronary stent implantation. The primary combined end point was death due to cardiac causes, myocardial infarction related to the target vessel and repeat intervention of the stented vessel. RESULTS: Grouping patients into tertiles according to preprocedural CRP levels revealed that, despite identical angiographic and clinical characteristics at baseline and after stent implantation, a primary end point event occurred in 24 (26%) patients of the lowest tertile, in 42 (45.6%) of the middle tertile and in 38 (41.3%) of the highest CRP tertile, p = 0.01. On multivariate analysis, tertiles of CRP levels were independently associated with a higher risk of adverse coronary events (relative risk = 2.0 [1.1 to 3.5], tertile I vs. II and III, p = 0.01) in addition to the minimal lumen diameter after stent (p = 0.04). In addition, restenosis rates were significantly higher in the two upper tertiles compared with CRP levels in the lowest tertile (45.5% vs. 38.3% vs. 18.5%, respectively, p = 0.002). CONCLUSIONS: Low-grade inflammation as evidenced by elevated preprocedural serum CRP levels is an independent predictor of adverse outcome after coronary stent implantation, suggesting that a systemically detectable inflammatory activity is associated with proliferative responses within successfully implanted stents.
BACKGROUND: The DD genotype for the angiotensin-I converting enzyme (ACE I) deletion allele (D) polymorphism is a possible genetic risk factor for restenosis after coronary stent implantation. We aimed to establish whether or not blockade of ACE with high doses of ACE inhibitors could reduce this risk of angiographic restenosis.

METHODS: We characterised the ACE I/D polymorphism in 345 consecutive patients who were undergoing coronary stenting. 115 had the DD genotype. We assigned 91 of these 115 patients to quinapril 40 mg daily (n=46) or placebo (n=45). Treatment was started within 48 h after stent implantation and continued for 6 months. 79 patients complied with the protocol and underwent follow-up angiography after 6 months.

FINDINGS: Our primary endpoint of late loss in minimum lumen diameter (a quantitative index of restenosis) was significantly higher in the quinapril group than in the controls (mean 1.11 mm [SD 0.70] vs 0.76 mm [0.60]; p=0.018). Secondary endpoints also showed consistent trends towards increased angiographic restenosis in the treatment group.

INTERPRETATION: Contrary to our expectations, ACE inhibitor treatment did not reduce restenosis after coronary stent implantation in patients with DD genotype, but was associated with an exaggerated restenotic process when compared with administration of placebo.

Circulation 2001 Apr 3;103(13):1740-5

Relationship between neointimal thickness and shear stress after Wallstent implantation in human coronary arteries.


BACKGROUND: In-stent restenosis by excessive intimal hyperplasia reduces the long-term clinical efficacy of coronary stents. Because shear stress (SS) is related to plaque growth in atherosclerosis, we investigated whether variations in SS distribution are related to variations in neointima formation.

METHODS AND RESULTS: In 14 patients, at 6-month follow-up after coronary Wallstent implantation, 3D stent and vessel reconstruction was performed with a combined angiographic and intravascular ultrasound technique (ANGUS). The bare stent reconstruction was used to calculate in-stent SS at implantation, applying
computational fluid dynamics. The flow was selected to deliver an average SS of 1.5 N/m². SS and neointimal thickness (Th) values were obtained with a resolution of 90 degrees in the circumferential and 2.5 mm in the longitudinal direction. For each vessel, the relationship between Th and SS was obtained by linear regression analysis. Averaging the individual slopes and intercepts of the regression lines summarized the overall relationship. Average Th was 0.44±0.20 mm. Th was inversely related to SS: Th=(0.59±0.24)-(0.08±0.10)xSS (mm) (P<0.05). CONCLUSIONS: These data show for the first time in vivo that the Th variations in Wallstents at 6-month follow-up are inversely related to the relative SS distribution. These findings support a hemodynamic mechanism underlying in-stent neointimal hyperplasia formation.

Circulation 2001 May 15;103(19):2332-5

Prolonged antiplatelet therapy to prevent late thrombosis after intracoronary gamma-radiation in patients with in-stent restenosis: Washington Radiation for In-Stent Restenosis Trial plus 6 months of clopidogrel (WRIST PLUS).


BACKGROUND: Intracoronary gamma-radiation reduces recurrent in-stent restenosis. Late thrombosis (>30 days after radiation therapy) is identified as a serious complication. The Washington Radiation for In-Stent Restenosis Trial (WRIST) PLUS, which involved 6 months of treatment with clopidogrel and aspirin, was designed to examine the efficacy and safety of prolonged antiplatelet therapy for the prevention of late thrombosis. Methods and RESULTS: A total of 120 consecutive patients with diffuse in-stent restenosis in native coronary arteries and vein grafts with lesions <80 mm underwent percutaneous coronary transluminal angioplasty, laser ablation, and/or rotational atherectomy. Additional stents were placed in 34 patients (28.3%). After the intervention, a closed-end lumen catheter was introduced into the artery, a ribbon with different trains of radioactive (192)Ir seeds was positioned to cover the treated site, and a dose of 14 Gy to 2 mm was prescribed. Patients were discharged with clopidogrel and aspirin for 6 months and followed angiographically and clinically. All patients but one tolerated the clopidogrel. The late occlusion and thrombosis rates were compared with the gamma-radiation-treated (n=125) and the placebo patients (n=126) from the WRIST and LONG WRIST studies (which involved only 1 month of antiplatelet therapy). At 6 months, the group receiving prolonged antiplatelet therapy had total occlusion and late thrombosis rates of 5.8% and 2.5%, respectively;
these rates were lower than those in the active gamma-radiation group and similar to those in the placebo historical control group. CONCLUSIONS: Six months of clopidogrel and aspirin and a reduction in re-stenting for patients with in-stent restenosis treated with gamma-radiation is well tolerated and associated with a reduction in the late thrombosis rate compared with a similar cohort treated with only 1 month of clopidogrel and aspirin.

Circulation 2001 May 1;103(17):2130-2

Impact of peri-stent remodeling on restenosis: a volumetric intravascular ultrasound study.


BACKGROUND: Vessel remodeling is an important mechanism of late lumen loss after nonstent coronary interventions. However, its impact on in-stent restenosis has not been systematically investigated. METHODS AND RESULTS: Serial volumetric intravascular ultrasound analyses (poststent and follow-up) were performed in 55 lesions treated with a balloon-expandable stent (ACS MultiLink) using standard stent deployment techniques. The vessel volume (VV), lumen volume (LV), and volume bordered by the stent (SV) were measured using Simpson’s method. The volume of plaque and neointima outside the stent (peri-stent volume, PSV) and volume of neointima within the stent (intrastent volume) were also measured. The change of each parameter during the follow-up period (follow-up minus poststent) was calculated and then divided by SV to normalize these values (designated as percent change [%]). As expected, %PSV directly correlated with %VV (P<0.0001, r=0.935), with no significant SV. A highly significant inverse correlation was seen between %PSV and the percent change of intrastent volume (P<0.0001, r=0.517). Consequently, %LV significantly correlated with peri-stent remodeling, as measured by %VV (P<0.0001, r=0.602). CONCLUSION: Positive remodeling of the vessel exterior to a coronary stent occurs to a variable degree after stent implantation. There is a distinct trade-off between positive remodeling and in-stent hyperplasia: in segments in which the degree of peri-stent remodeling is less, intrastent neointimal proliferation is greater and accompanied by more significant late lumen loss.

J Am Coll Cardiol 2001 May;37(6):1598-603
Continued benefit of coronary stenting versus balloon angioplasty: five-year clinical follow-up of Benestent-I trial.


OBJECTIVES: This study sought to establish whether the early favorable results in the Benestent-I randomized trial comparing elective Palmaz-Schatz stent implantation with balloon angioplasty in 516 patients with stable angina pectoris are maintained at 5 years. BACKGROUND: The size of the required sample was based on a 40% reduction in clinical events in the stent group. Seven months and one-year follow-up in this trial showed a decreased incidence of restenosis and clinical events in patients randomized to stent implantation. METHODS: Data at five years were collected by outpatient visit, via telephone and via the referring cardiologist. Three patients in the stent group and one in the percutaneous transluminal coronary angioplasty (PTCA) group were lost to follow-up at five years. Major clinical events, anginal status and use of cardiac medication were recorded according to the intention to treat principle. RESULTS: No significant differences were found in anginal status and use of cardiac medication between the two groups. In the PTCA group, 27.3% of patients underwent target lesion revascularization (TLR) versus 17.2% of patients in the stent group (p = 0.008). No significant differences in mortality (5.9% vs. 3.1%), cerebrovascular accident (0.8% vs. 1.2%), myocardial infarction (9.4% vs. 6.3%) or coronary bypass surgery (11.7% vs. 9.8%) were found between the stent and PTCA groups, respectively. At five years, the event-free survival rate (59.8% vs. 65.6%; p = 0.20) between the stent and PTCA groups no longer achieved statistical significance. CONCLUSIONS: The original 10% absolute difference in TLR in favor of the stent group has remained unchanged at five years, emphasizing the long-term stability of the stented target site.

Lancet 2001 Jun 30;357(9274):2085-9

Treatment of Chlamydia pneumoniae infection with roxithromycin and effect on neointima proliferation after coronary stent placement (ISAR-3): a randomised, double-blind, placebo-controlled trial.

BACKGROUND: Vascular infection with Chlamydia pneumoniae might boost inflammatory responses that play a pivotal part in neointima formation, which is the main cause of restenosis after stenting. Our aim was to investigate whether or not treatment of C pneumoniae infection with antibiotics prevents restenosis after coronary stent placement. METHODS: We enrolled 1010 consecutive patients with successful coronary stenting into a randomised, double-blind trial. Patients received the macrolide antibiotic roxithromycin 300 mg once daily for 28 days (506), or placebo (504). Primary endpoint was frequency of restenosis (diameter stenosis >50%) at follow-up angiography, and secondary endpoint was rate of target vessel revascularisation during the year after stenting. A prespecified secondary analysis addressed treatment effect with respect to titre of C pneumoniae in serum. Analysis was by intention to treat. FINDINGS: Rate of angiographic restenosis was 31% (157 lesions) in the roxithromycin group and 29% (148) in the placebo group (relative risk 1.08 [95% CI 0.92-1.26]; p=0.43), corresponding to a rate of target vessel revascularisation of 19% (120) and 17% (105), respectively (1.13 [0.95-1.36]; p=0.30). The combined 1-year rates of death and myocardial infarction were 7% (36) in the roxithromycin group and 6% (30) in the placebo group (p=0.45). We showed a significant interaction between treatment and C pneumoniae antibody titre (p=0.038 for restenosis, p=0.006 for revascularisation), favouring roxithromycin at high titres (adjusted odds ratios at a titre of 1/512 were 0.44 [0.19-1.06] and 0.32 [0.13-0.81], respectively). INTERPRETATION: Non-selective use of roxithromycin is inadequate for prevention of restenosis after coronary stenting. There is, however, a differential effect dependent on C pneumoniae titres. In patients with high titres, roxithromycin reduced the rate of restenosis.

J Am Coll Cardiol 2001 Jun 15;37(8):2066-73

Incidence of thrombotic occlusion and major adverse cardiac events between two and four weeks after coronary stent placement: analysis of 5,678 patients with a four-week ticlopidine regimen.

Schuhlen H, Kastrati A, Pache J, Dirschinger J, Schomig A.

OBJECTIVES: We attempted to make a comprehensive assessment of the risk of stent failure (death, myocardial infarction or angiographically documented occlusion), differentiating early (first and second weeks) and late (third and fourth weeks) events. BACKGROUND: The risk of stent failure decreases rapidly within the first week. It has been suggested that the risk rate for late events is close to 0% and that the thienopyridine regimen
(ticlopidine or clopidogrel) could be safely reduced from four to two weeks, minimizing the risk of hematological complications. METHODS: We analyzed 5,678 patients with successful coronary stent placement and a four-week ticlopidine regimen. RESULTS: The rate of stent failure was 2.5% at four weeks, with 112 early (2.0%) and 30 late events (0.5%). Multivariate analysis identified different risk factors for early versus late events. While variables on stenosis severity and procedural results that can be influenced by the operator were identified as independent risk factors for early events (percent stenosis before and after the procedure, residual dissection, length of stented segment), more clinical variables were associated with late events (age, reduced left ventricular function, systemic hypertension as a protective factor). The late-event rate was <0.1% in the absence of these factors, but it was 2.5% with all three risk factors present. CONCLUSIONS: The risk of late stent failure is low with a four-week ticlopidine regimen. However, high-risk subgroups have a risk of 2.5%. As this rate is presumably higher if thienopyridines are discontinued after two weeks, these data suggest that a risk stratification to a two- or four-week regimen is preferable to a general reduction.

J Am Coll Cardiol 2001 Jun 15;37(8):2059-65

Long-term mortality benefit with abciximab in patients undergoing percutaneous coronary intervention.


OBJECTIVES: The goal of this study was to test: 1) if platelet glycoprotein IIb/IIIa (GP IIb/IIIa) blockade with abciximab bolus plus 12-h infusion reduces mortality after percutaneous coronary intervention (PCI); 2) if prevention of early myocardial infarction (MI) after PCI is a mechanism for reducing mortality; and 3) for risk factors for mortality after PCI. BACKGROUND: Studies of PCI suggest that MI after intervention is predictive of mortality. Abciximab, a platelet GP IIb/IIIa receptor inhibitor, has consistently reduced the incidence of MI among PCI patients in several trials. The presumed mechanism is prevention of platelet thrombus associated with vessel wall injury and downstream embolization into the microcirculation. METHODS: In eight trials, 5,154 patients were randomized to a regimen comprising conventional therapy plus a bolus of abciximab within 1 h before PCI followed by a 12-h infusion; 4,136 controls were randomized to conventional therapy alone. Patient follow-up from six months to three years was available. Survival differences are examined using proportional hazards regression and survival curves. RESULTS: A hazard ratio of 0.71 (95% confidence interval 0.57 to 0.89; p = 0.003) suggests a mortality benefit with abciximab. The absolute reduction in mortality was
estimated to be 0.5% through 30 days, 0.7% through six months, 0.9% through one year and 1.8% through three years. Early MI explained 18% of the observed mortality benefit at one year. Multivariate regression suggests that patients with advanced cardiovascular disease may derive the greatest mortality benefit from abciximab.

CONCLUSIONS: The evidence from 9,290 randomized PCI patients shows a mortality benefit provided by abciximab bolus plus 12-h infusion.

Circulation 2001 Jun 12;103(23):2816-21

Intracoronary stenting and angiographic results: strut thickness effect on restenosis outcome (ISAR-STEREO) trial.


BACKGROUND: Increased thrombogenicity and smooth muscle cell proliferative response induced by the metal struts compromise the advantages of coronary stenting. The objective of this randomized, multicenter study was to assess whether a reduced strut thickness of coronary stents is associated with improved follow-up angiographic and clinical results. METHODS AND RESULTS: A total of 651 patients with coronary lesions situated in native vessels >2.8 mm in diameter were randomly assigned to receive 1 of 2 commercially available stents of comparable design but different thickness: 326 patients to the thin-strut stent (strut thickness of 50 microm) and 325 patients to the thick-strut stent (strut thickness of 140 microm). The primary end point was the angiographic restenosis (>/=50% diameter stenosis at follow-up angiography). Secondary end points were the incidence of reinterventions due to restenosis-induced ischemia and the combined rate of death and myocardial infarctions at 1 year. The incidence of angiographic restenosis was 15.0% in the thin-strut group and 25.8% in the thick-strut group (relative risk, 0.58; 95% CI, 0.39 to 0.87; P=0.003). Clinical restenosis was also significantly reduced, with a reintervention rate of 8.6% among thin-strut patients and 13.8% among thick-strut patients (relative risk, 0.62; 95% CI, 0.39 to 0.99; P=0.03). No difference was observed in the combined 1-year rate of death and myocardial infarction. CONCLUSIONS: The use of a thinner-strut device is associated with a significant reduction of angiographic and clinical restenosis after coronary artery stenting. These findings may have relevant implications for the currently most widely used percutaneous coronary intervention.
OBJECTIVE: We examined long-term outcomes of patients with in-stent restenosis (ISR) who underwent different percutaneous interventions at the discretion of individual operators: balloon angioplasty (BA), repeat stent or rotational atherectomy (RA). We also examined long-term outcomes of patients with ISR who underwent coronary artery bypass surgery (CABG). BACKGROUND: In-stent restenosis remains a challenging problem, and its optimal management is still unknown. METHODS: Symptomatic patients (n = 510) with ISR were identified using cardiac catheterization laboratory data. Management for ISR included BA (169 patients), repeat stenting (117 patients), RA (107 patients) or CABG (117 patients). Clinical outcome events of interest included death, myocardial infarction, target vessel revascularization (TVR) and a combined end point of these major adverse cardiovascular events (MACE). Mean follow-up was 19+/−12 months (range = 6 to 61 months). RESULTS: Patients with ISR treated with repeat stent had significantly larger average post-procedure minimal lumen diameter compared with BA or RA (3.3+/−0.4 mm vs. 3.0+/−0.4 vs. 2.9+/−0.5, respectively, p < 0.05). Incidence of TVR and MACE were similar in the BA, stent and RA groups (39%, 40%, 33% for TVR and 43%, 40%, 33% for MACE, p = NS). Patients with diabetes who underwent RA had similar outcomes as patients without diabetes, while patients with diabetes who underwent BA or stent had worse outcomes than patients without diabetes. Patients who underwent CABG for ISR, mainly because of the presence of multivessel disease, had significantly better outcomes than any percutaneous treatment (8% for TVR and 23% for MACE). CONCLUSIONS: In this large cohort of patients with ISR and in the subset of patients without diabetes, long-term outcomes were similar in the BA, repeat stent and RA groups. Tissue debulking with RA yielded better results only in diabetic patients. Bypass surgery for patients with multivessel disease and ISR provided the best outcomes.
Long-term (> or ≥ 8 years) outcome after Palmaz-Schatz stent implantation.


The purpose of this single-center study was to evaluate the long-term (> or ≥ 8 years) outcome of Palmaz-Schatz intracoronary stenting and to identify independent predictors of outcome. Although short-term results of Palmaz-Schatz intracoronary stenting have been promising, with a reduction in both angiographic restenosis and clinical cardiac events up to 3 years, longer-term follow-up has not been established. We analyzed clinical outcome in 426 consecutive patients at least 8 years after coronary stenting. Demographic, clinical, and procedural predictors of restenosis, survival, and event-free survival, defined as freedom from death, myocardial infarction (MI), and coronary revascularization (target stented site, target vessel, and any revascularization) were analyzed. Before discharge, 28 patients (6.6%) sustained at least 1 major cardiovascular event: 3 deaths (0.7%), 18 MIs (4.2%), and 17 repeat revascularizations. Surviving patients were followed for 8.9 years (interquartile range 8.4 to 9.4). After discharge, 59 patients (13.9%) died, 47 (11.1%) sustained an MI, and 188 (44.4%) underwent coronary revascularization. The 8-year event-free survival (freedom from death, freedom from death/MI/target-stented site revascularization, and freedom from death/MI/any coronary revascularization) was (mean ± SE) 0.86 ± 0.01, 0.62 ± 0.03, and 0.47 ± 0.02, respectively. Unstable angina, lower left ventricular ejection fraction, and saphenous vein graft stenting were found to be independent predictors of death during follow-up. Hypertension, unstable angina, multivessel disease, and multiple stent implantation were found to be independent predictors of the composite of death/MI/any coronary revascularization during follow-up. This study provided a useful assessment of very long-term outcome in survival, event-free survival, and predictors of major cardiac events 8 to 10 years after Palmaz-Schatz stent implantation.

Am J Cardiol 2001 Aug 1;88(3):253-9

Comparison of self-expanding and balloon-expandable stents for the reduction of restenosis.

To compare the efficacy of self-expanding (SE) and balloon-expandable (BE) stents in native coronary arteries, we randomly assigned 1,096 patients with new and restenotic lesions to receive either device. Baseline demographics and coronary angiographic characteristics were similar in the 2 groups. The incidence of major adverse cardiac events including death, myocardial infarction, bypass surgery, and repeat intervention was similar for both groups at 1 month (2.9% vs 3.1% for SE vs BE, respectively) and at 9 months (19.3% vs 20.1%, SE vs BE respectively). In a subgroup of patients who underwent follow-up angiography (n = 250), the binary restenosis rates (24.2% vs 18.7%, p = 0.30), late loss (0.98 vs 94 mm, p = 0.60), and loss index (0.55 vs 55, p = 0.95) were not significantly different for both groups. In 62 patients who underwent intravascular ultrasound examination (IVUS), there was a trend toward a lower incidence of edge tears in the SE group (6% vs 23%, p = 0.06). Follow-up IVUS analysis showed that the minimum stent area of the SE stent increased by 33% at 6 months, whereas no change occurred in the BE stents; this was accompanied by a greater degree of intimal proliferation in the SE stents compared with BE stents (3.1 +/- 2.0 vs 1.7 +/- 1.7 mm(2)). Thus, the SE stents had similar clinical and angiographic outcomes in patients with lesions in native coronary arteries.

Am J Cardiol 2001 Aug 1;88(3):248-52

Extent and distribution of in-stent intimal hyperplasia and edge effect in a non-radiation stent population.


Intimal hyperplasia within the body of the stent is the primary mechanism for in-stent restenosis; however, stent edge restenosis has been described after brachytherapy. Our current understanding about the magnitude of in vivo intimal hyperplasia and edge restenosis is limited to data obtained primarily from select, symptomatic patients requiring repeat angiography. The purpose of this study was to determine the extent and distribution of intimal hyperplasia both within the stent and along the stent edge in relatively nonselect, asymptomatic patients scheduled for 6-month intravascular ultrasound (IVUS) as part of a multicenter trial: Heparin Infusion Prior to Stenting. Planar IVUS measurements 1 mm apart were obtained throughout the stent and over a length of 10 mm proximal and distal to the stent at index and follow-up. Of the 179 patients enrolled, 140 returned for repeat angiography and IVUS at 6.4 +/- 1.9 months and had IVUS images adequate for analysis. Patients had 1.2 +/- 0.6 Palmaz-Schatz stents per vessel. There was a wide individual variation of intimal hyperplasia distribution within the stent and no mean predilection for any location. At 6 months, intimal
hyperplasia occupied 29.3 +/- 16.2% of the stent volume on average. Lumen loss within 2 mm of the stent edge was due primarily to intimal proliferation. Beyond 2 mm, negative remodeling contributed more to lumen loss. Gender, age, vessel location, index plaque burden, hypercholesterolemia, diabetes, and tobacco did not predict luminal narrowing at the stent edges, but diabetes, unstable angina at presentation, and lesion length were predictive of in-stent intimal hyperplasia. In a non-radiation stent population, 29% of the stent volume is filled with intimal hyperplasia at 6 months. Lumen loss at the stent edge is due primarily to intimal proliferation.

Circulation 2001 Sep 18;104(12):1343-9

Randomized comparison of coronary stent implantation under ultrasound or angiographic guidance to reduce stent restenosis (OPTICUS Study).


BACKGROUND: Observational studies in selected patients have shown remarkably low restenosis rates after ultrasound-guided stent implantation. However, it is unknown whether this implantation strategy improves long-term angiographic and clinical outcome in routine clinical practice. Methods and Results?A total of 550 patients with a symptomatic coronary lesion or silent ischemia were randomly assigned to either ultrasound-guided or angiography-guided implantation of <=2 tubular stents. The primary end points were angiographic dichotomous restenosis rate, minimal lumen diameter, and percent diameter stenosis after 6 months as determined by quantitative coronary angiography. Secondary end points were the occurrence rates of major adverse cardiac events (death, myocardial infarction, coronary bypass surgery, and repeat percutaneous intervention) after 6 and 12 months of follow-up. At 6 months, repeat angiography revealed no significant differences between the groups with ultrasound- or angiography-guided stent implantation with respect to dichotomous restenosis rate (24.5% versus 22.8%, P=0.68), minimal lumen diameter (1.95+/-.0.72 mm versus 1.91+/-.0.68 mm, P=0.52), and percent diameter stenosis (34.8+/20.6% versus 36.8+/19.6%, P=0.29), respectively. At 12 months, neither major adverse cardiac events (relative risk, 1.07; 95% CI 0.75 to 1.52; P=0.71) nor repeat percutaneous interventions (relative risk 1.04; 95% CI 0.64 to 1.67; P=0.87) were reduced in the ultrasound-guided group. CONCLUSIONS: This study does not support the routine use of ultrasound guidance for coronary stenting. Angiography-guided optimization of tubular stents can be performed with comparable
ANGIOGRAPHIC AND CLINICAL LONG-TERM RESULTS.

Am Heart J 2001 Sep;142(3):445-51

Does stent design affect probability of restenosis? A randomized trial comparing Multilink stents with GFX stents.


BACKGROUND: Experimental studies have revealed that stent configuration influences intimal hyperplasia. The purpose of this study was to evaluate clinical outcomes for 2 stent designs in a randomized trial with quantitative coronary angiography (QCA) and intravascular ultrasonography (IVUS). METHODS: We randomly assigned 100 patients with 107 lesions and symptomatic coronary artery disease to deployment of a Multilink stent (Advanced Cardiovascular Systems, Guidant, Santa Clara, Calif) or a GFX stent (Applied Vascular Engineering, Santa Rosa, Calif) with IVUS guidance. QCA and IVUS studies were performed before and after intervention and at follow-up (4.2 +/- 1.0 months). RESULTS: There were no significant differences in baseline characteristics and QCA and IVUS parameters before and after intervention between the 2 groups. However, minimal lumen diameter at follow-up was significantly larger in the Multilink group (2.46 +/- 0.59 vs 2.08 +/- 0.79 mm, P <.05). Maximal in-stent intimal hyperplasia was significantly larger in the GFX group (2.9 +/- 1.7 vs 1.8 +/- 1.2 mm(2), P <.01). The restenosis rate differed between the 2 groups (Multilink 4% vs GFX 26%, P =.003). In multiple stepwise logistic regression analysis, the only predictor that significantly correlated with restenosis was stent type (P <.01). The odds ratio for the GFX stent-treated vessels was 18.65 (95% confidence interval 2.10-165.45). CONCLUSIONS: With deployment of the GFX stent, a thicker neointima develops within the stent. Stent configuration may affect clinical outcomes.

Heart 2001 Sep;86(3):302-8

RANDOMISED COMPARISON OF CORONARY STENTING WITH AND WITHOUT BALLOON PREDILATATION IN SELECTED PATIENTS.


BACKGROUND: The SWIBAP (stent without balloon predilatation) prospective randomised trial was designed to compare direct coronary stenting with stenting preceded by lesion predilatation with an angioplasty balloon. OBJECTIVE: To determine the feasibility and safety of direct stenting in non-complex coronary lesions in a prospective study. PATIENTS AND DESIGN: All patients < 76 years of age scheduled to undergo angioplasty of a non-complex, non-calcified lesion in a coronary artery of > 3.0 mm, who granted their informed consent, were randomised into the trial. In group I, the stent was placed without balloon predilatation, while in group II stent implantation was preceded by balloon predilatation. The primary end point was the angiographic result according to procedure assigned by randomisation. An intravascular ultrasound substudy was performed in 60 patients. RESULTS: Stent implantation was successful without predilatation in 192 of the 197 group I patients (97.5%), and with predilatation in 197 of the 199 group II patients (99%) (NS). No in-hospital stent thrombosis or death occurred. Overall procedural times, fluoroscopy times, and volumes of contrast agent given (mean (SD)) in group I v group II were 23.50 (13.54) min v 27.96 (15.23) min (p = 0.002), 6.04 (4.13) min v 6.67 (3.65) min (NS), and 135 (65) ml v 157 (62) ml (p < 0.001), respectively. No major adverse cardiovascular events had occurred by 30 days. CONCLUSIONS: The feasibility and safety of direct stenting of selected and non-complex coronary lesions is confirmed. This technique was as successful as the conventional approach and was associated with a minor reduction in fluoroscopic exposure and procedure time and the administration of less contrast agent.


The TRAPIST Study. A multicentre randomized placebo controlled clinical trial of trapidil for prevention of restenosis after coronary stenting, measured by 3-D intravascular ultrasound.

Serruys PW, Foley DP, Pieper M, Kleijne JA, de Feyter on behalf of the TRAPIST investigators PJ.

Background Studies have reported benefit of oral therapy with the phosphodiesterase inhibitor, trapidil, in reducing restenosis after coronary angioplasty. Coronary stenting is associated with improved late outcome
compared with balloon angioplasty, but significant neointimal hyperplasia still occurs in a considerable proportion of patients. The aim of this study was to investigate the safety and efficacy of trapidil 200 mg in preventing in-stent restenosis.

Methods Patients with a single native coronary lesion requiring revascularization were randomized to placebo or trapidil at least 1 h before, and continuing for 6 months after, successful implantation of a coronary Wallstent. The primary end-point was in-stent neointimal volume measured by three-dimensional reconstruction of intravascular ultrasound images recorded at the 6 month follow-up catheterization.

Results Of 312 patients randomized at 21 centres in nine countries, 303 (148 trapidil, 155 placebo) underwent successful Wallstent implantation, and 139 patients (90%) in the placebo group and 130 (88%) in the trapidil group had repeat catheterization at 26+/2 weeks. There was no significant difference between trapidil and placebo-treated patients regarding in-stent neointimal volume (108.6+/- 95.6 mm(3) vs 93.3+/-.79.1 mm(3);P=0.16) or % obstruction volume (38+/-.18% vs 36+/-.21%;P=0.32), in angiographic minimal luminal diameter at follow-up (1.63+/-.061 mm vs 1.74+/-.069 mm;P=0.17), restenosis rate (31% vs 24%;P=0.24), cumulative incidence of major adverse cardiac events at 7 months (22% vs 20%;P=0.71) or anginal complaints (30% vs 24%;P=0.29).

Conclusion Oral trapidil 600 mg daily for 6 months did not reduce in-stent hyperplasia or improve clinical outcome after successful Wallstent implantation and is not indicated for this purpose.


Direct coronary stenting without balloon or device pretreatment: acute success and long-term results.

Stys T, Lawson WE, Liuzzo JP, Hanif B, Bragg L, Cohn PF.

Improvements in coronary stents have made planned direct coronary stenting technically feasible, though safety, acute success, cost-effectiveness, and long-term results remain to be determined. Sequential patients eligible for direct stenting were prospectively characterized and treated with either direct or secondary stenting. Major adverse cardiovascular events (MACE) such as cardiac death, myocardial infarction (MI), target vessel ischemia, or revascularization (TVR) were followed for 6 months post-PCI. Enrollment included 128 direct (1.38 lesions/patient) and 69 secondary (1.39 lesions/patient) stented patients. Direct stenting was successful in 99% (with 5% crossover to secondary stenting) without major procedural complications and with a similar rate of vessel wall dissection or no-reflow phenomenon (2.3% vs. 2.1%; P > 0.05) as the secondary stenting group. There was a trend toward less postprocedural CPK-MB elevation in the nonacute MI patients with direct vs. secondary stenting (3% vs. 11%, respectively). At 6 months, there were no statistically significant differences in
overall MACE. Direct stenting has a high success rate, low complication rate, and durable long-term results. Procedural cost and time savings, less contrast use and radiation exposure make direct stenting attractive in properly selected patients. Copyright 2001 Wiley-Liss, Inc.

Circulation 2001 Oct 2;104(14):1604-8

Stent placement compared with balloon angioplasty for small coronary arteries: in-hospital and 6-month clinical and angiographic results.


BACKGROUND: Stenting has been demonstrated to be superior to balloon angioplasty in de novo focal lesions located in large native vessels. However, in small vessels, the benefit of stenting remains questionable. METHODS AND RESULTS: A total of 381 symptomatic patients with de novo focal lesion located on a small coronary segment vessel (<3 mm) were randomly assigned to either stent implantation (192 patients; 197 lesions) or standard balloon angioplasty (189 patients; 198 lesions). The primary end point was the angiographic restenosis rate at 6 months, as determined by quantitative coronary angiography. On intention-to-treat analysis, angiographic success rate and major adverse cardiac events were comparable: 97.9% and 4.6% versus 93.9% and 5.8% in the stent group and the balloon group, respectively. After the procedure, a larger acute gain was achieved with stent placement (1.35±0.45 versus 0.94±0.47 mm, P=0.0001), resulting in a larger minimal lumen diameter (2.06±0.42 versus 1.70±0.46 mm, P=0.0001). At follow-up (obtained in 91% of patients), angiographic restenosis rate was 21% in the stent group versus 47% in the balloon group (P<0.0001), a risk reduction of 55%. Repeat target lesion revascularization was less frequent in the stent group (13% versus 25%, P=0.0006). CONCLUSIONS: Elective stent placement in small coronary arteries with focal de novo lesions is safe and associated with a marked reduction in restenosis rate and subsequent target lesion revascularization rate at 6 months.

Circulation 2001 Oct 23;104(17):2029-33
Stent placement to prevent restenosis after angioplasty in small coronary arteries.


BACKGROUND: Lesions in small-diameter vessels (<3 mm) define a group with distinct clinical and morphological characteristics. There is an inverse relationship between vessel size and angiographic restenosis rate. This study assessed whether stents reduce angiographic restenosis in small coronary arteries compared with standard balloon angioplasty. METHODS AND RESULTS: We randomly assigned 351 symptomatic patients needing dilatation of 1 native coronary vessel between 2.3 and 2.9 mm in size to angioplasty alone (n=182) or stent implantation (n=169). The primary end point was angiographic restenosis at 6 months. Secondary end points included death, myocardial infarction, bypass surgery, and target vessel revascularization in hospital and at 6 months. There were no significant differences between groups in terms of major in-hospital complications. There was a trend toward fewer in-hospital events in the stent group (3% versus 7.1% in angioplasty group, P=0.076). Crossovers to stent occurred in 37 patients (20.3%). Repeat angiography at 6-month follow-up was performed in 85.3% of patients. Angiographic restenosis occurred in 28% of the stent group and 32.9% of the angioplasty group (P=0.36). Target vessel revascularization was required in 17.8% versus 20.3% of patients (P=0.54), respectively. CONCLUSIONS: Stenting and standard coronary angioplasty are associated with equal restenosis rate in small coronary arteries. With a lower in-hospital complication rate, stenting may be a superior strategy in small vessels.

J Am Coll Cardiol 2001 Nov 15;38(6):1598-603

Stenting in small coronary arteries (SISCA) trial. A randomized comparison between balloon angioplasty and the heparin-coated beStent.


OBJECTIVES: The purpose of this study was to assess the clinical and angiographic benefits of elective stenting in coronary arteries with a reference diameter of 2.1 to 3.0 mm, as compared with traditional percutaneous
transluminal coronary angioplasty (PTCA). BACKGROUND: The problems related to small-vessel stenting might be overcome using modern stents designed for small vessels, combined with effective antiplatelet therapy. METHODS: In five centers, 145 patients with stable or unstable angina were randomly assigned to elective stenting treatment with the heparin (Heparomed)-coated beStent or PTCA. Control angiography was performed after six months. The primary end point was the minimal lumen diameter (MLD) at follow-up. Secondary end points were the restenosis rate, event-free survival and angina status. RESULTS: At follow-up, there was a trend toward a larger MLD in the stent group (1.69 +/- 0.52 mm vs. 1.57 +/- 0.44 mm, p = 0.096). Event-free survival at follow-up was significantly higher in the stent group: 90.5% vs. 76.1% (p = 0.016). The restenosis rate was low in both groups (9.7% and 18.8% in the stent and PTCA groups, respectively; p = 0.15). Analyzed as treated, both the MLD and restenosis rate were significantly improved in patients who had stents as compared with PTCA. CONCLUSIONS: In small coronary arteries, both PTCA and elective stenting are associated with good clinical and angiographic outcomes after six months. Compared with PTCA, elective treatment with the heparin-coated beStent improves the clinical outcome; however, there was only a nonsignificant trend toward angiographic improvement.

J Am Coll Cardiol 2001 Nov 1;38(5):1434-9


OBJECTIVES: This study aimed to clarify the role of the angiotensin-converting enzyme (ACE) gene polymorphism in the development of in-stent restenosis. BACKGROUND: In-stent restenosis occurs after treatment of coronary artery stenosis in 12% to 32% of coronary interventions with stents. Experimental and clinical studies have suggested that the deletion/insertion (D/I) polymorphism of the ACE gene plays a role in this. METHODS: Quantitative coronary angiography before, immediately after and six months after stent implantation were compared in 369 patients, in whom D/I typing of the ACE gene was performed. RESULTS: At follow-up we found no differences between the three genotypes in minimal lumen diameter (homozygotes with two deletion alleles in the ACE gene [DD], 2.20 mm; heterozygotes with one deletion and one insertion allele in the ACE gene [DI], 2.19 mm; and homozygotes with two insertion alleles in the ACE gene [II], 2.25
mm). The corresponding diameter stenoses were: DD: 25%, DI: 27%, II: 27% (p = NS), and the frequency of restenosis (>50% diameter stenosis) was: DD: 15.7%, DI: 11.0% and II: 16.4% (p = NS). Logistic regression analysis identified diabetes (odds ratio [OR]: 3.0, 95% confidence interval [CI]: 1.0 to 8.7), lesion length (OR: 1.1, 95% CI: 1.01 to 1.30) and minimal lumen diameter immediately after the intervention (OR: 0.3, 95% CI: 0.14 to 0.85) as predictors of in-stent restenosis. In a post hoc analysis of patients treated versus those not treated with an ACE-inhibitor antagonist or an angiotensin receptor antagonist, we found an increased frequency of in-stent restenosis in the DD genotypes (40% vs. 12%, p = 0.006). CONCLUSIONS: The D/A polymorphism is not an independent predictor of coronary in-stent restenosis in general, but it may be of clinical importance in patients treated with ACE inhibitors or angiotensin receptor antagonists.


Predictors of length of stay after coronary stenting.

Aronow HD, Peyser PA, Eagle KA, Bates ER, Werns SW, Russman PL, Crum MA, Harris K, Moscucci M.

BACKGROUND: Postprocedure length of stay (LOS) remains an important determinant of medical costs after coronary stenting. Variables that predict LOS in this setting have not been well characterized. METHODS: We evaluated 359 consecutive patients who underwent coronary stenting with antiplatelet therapy. Sequential multiple linear regression (MLR) models were constructed with use of 4 types of variables to predict log-transformed LOS: preprocedure, intraprocedure, and postprocedure factors and adverse outcomes. RESULTS: Preprocedure factors alone explained more than one third of the variability in postprocedure LOS (adjusted R(2) = 0.37). The addition of procedural variables added little to the model (adjusted R(2) = 0.39). Entering nonoutcome postprocedure variables significantly enhanced the predictive capacity of the model, explaining more than half the variability in postprocedure LOS (adjusted R(2) = 0.54). In the final model, addition of outcome variables increased its predictive capacity only slightly (adjusted R(2) = 0.61). In this model, significant preprocedure factors included: myocardial infarction (MI) within 24 hours, MI within 1 to 30 days, women with peripheral vascular disease, intravenous heparin, and chronic atrial fibrillation. High-risk intervention was the only significant intraprocedure variable. Significant postprocedure factors included periprocedure ischemia; cerebrovascular accident or transient ischemic attack; treatment with intravenous heparin or nitroglycerin or intra-aortic balloon pump; and need for blood transfusion. Significant adverse outcomes included contrast nephropathy, gastrointestinal bleeding, arrhythmia, vascular complication, and repeat
angiography. CONCLUSION: This prediction model identifies a number of potentially reversible factors responsible for prolonging LOS and may enable the development of more accurate risk-adjusted methods with which to improve or compare care.

Eur Heart J 2001 Nov;22(21):2015-24

The impact of high pressure vs low pressure stent implantation on intimal hyperplasia and follow-up lumen dimensions; results of a randomized trial.


Aims Histology and retrospective clinical studies have indicated that the amount of neointimal hyperplasia is dependent on the arterial injury induced during stent implantation. This study analysed, prospectively, the impact of high vs low pressure stent implantation techniques using a second generation stent on intimal hyperplasia and follow-up lumen dimensions. Methods and Results Post-intervention and follow-up (mean[+/- SD] 5.5+/1.3 months) angiographic and intravascular ultrasound studies were performed on 120 Multi-Link HP stents randomized to implantation at either low (8-10 atm) or high (16-20 atm) pressure. Intravascular ultrasound measurements of the external elastic membrane, stent, and lumen cross-sectional area were performed at 1 mm axial increments. Peri-stent plaque+media cross-sectional area (external elastic membrane-stent cross-sectional area, intimal hyperplasia cross-sectional area (stent-lumen cross-sectional area at follow-up), intimal hyperplasia thickness and peri-stent tissue growth cross-sectional area (Deltapersistent plaque+media cross-sectional area) were calculated. Intravascular ultrasound demonstrated a larger minimal lumen cross-sectional area post-intervention in the high pressure group (7.3+/2.0 vs 6.2+/1.8 mm(2), P<0.001, high vs low pressure group, respectively). At follow-up, the mean intimal hyperplasia cross-sectional area (1.7+/0.9 vs 1.5+/0.8 mm(2), P=0.708), the mean intimal hyperplasia thickness (0.16+/0.12 vs 0.16+/0.12 mm, P=0.818) and peri-stent tissue proliferation cross-sectional area were not greater in the high pressure group. Thus, the minimal lumen cross-sectional area at follow-up continued to be greater (5.5+/2.0 vs 4.7+/1.7 mm(2), P=0.038) in the high pressure group. Conclusions High pressure stent implantation results in greater stent expansion even with the less rigid second generation Multi-Link stent. Larger lumen dimensions persist at follow-up, while intimal hyperplasia is not significantly greater after high pressure implantation compared to the low pressure technique. Copyright 2001 The European Society of Cardiology.


OBJECTIVES: This study aimed to clarify the role of the angiotensin-converting enzyme (ACE) gene polymorphism in the development of in-stent restenosis. BACKGROUND: In-stent restenosis occurs after treatment of coronary artery stenosis in 12% to 32% of coronary interventions with stents. Experimental and clinical studies have suggested that the deletion/insertion (D/I) polymorphism of the ACE gene plays a role in this. METHODS: Quantitative coronary angiography before, immediately after and six months after stent implantation were compared in 369 patients, in whom D/I typing of the ACE gene was performed. RESULTS: At follow-up we found no differences between the three genotypes in minimal lumen diameter (homozygotes with two deletion alleles in the ACE gene [DD], 2.20 mm; heterozygotes with one deletion and one insertion allele in the ACE gene [DI], 2.19 mm; and homozygotes with two insertion alleles in the ACE gene [II], 2.25 mm). The corresponding diameter stenoses were: DD: 25%, DI: 27%, II: 27% (p = NS), and the frequency of restenosis (>50% diameter stenosis) was: DD: 15.7%, DI: 11.0% and II: 16.4% (p = NS). Logistic regression analysis identified diabetes (odds ratio [OR]: 3.0, 95% confidence interval [CI]: 1.0 to 8.7), lesion length (OR: 1.1, 95% CI: 1.01 to 1.30) and minimal lumen diameter immediately after the intervention (OR: 0.3, 95% CI: 0.14 to 0.85) as predictors of in-stent restenosis. In a post hoc analysis of patients treated versus those not treated with an ACE-inhibitor antagonist or an angiotensin receptor antagonist, we found an increased frequency of in-stent restenosis in the DD genotypes (40% vs. 12%, p = 0.006). CONCLUSIONS: The D/I polymorphism is not an independent predictor of coronary in-stent restenosis in general, but it may be of clinical importance in patients treated with ACE inhibitors or angiotensin receptor antagonists.

Circulation 2001 Dec 18;104(25):3039-45

Cost-effectiveness of coronary stenting in acute myocardial infarction: results from the stent primary angioplasty in myocardial infarction (stent-PAMI) trial.
Cohen DJ, Taira DA, Berezin R, Cox DA, Morice MC, Stone GW, Grines CL.

BACKGROUND: Although several randomized trials have demonstrated that coronary stenting improves angiographic and clinical outcomes for patients with acute myocardial infarction (AMI), the cost-effectiveness of this practice is unknown. The objective of the present study was to evaluate the long-term costs and cost-effectiveness (C/E) of coronary stenting compared with primary balloon angioplasty as treatment for AMI.

Methods and Results- Between December 1996 and November 1997, 900 patients with AMI were randomized to undergo balloon angioplasty (PTCA, n=448) or coronary stenting (n=452). Detailed resource utilization and cost data were collected for each patient’s initial hospitalization and for 1 year after randomization. Compared with conventional PTCA, stenting increased procedural costs by approximately $2000 per patient ($6538+/-1778 versus $4561+/-1598, P<0.001). During the 1-year follow-up period, stenting was associated with significant reductions in the need for repeat revascularization and rehospitalization. Although follow-up costs were significantly lower with stenting ($3613+/-7743 versus $4592+/-8198, P=0.03), overall 1-year costs remained approximately $1000/patient higher with stenting than with PTCA ($20 571+/-10 693 versus 19 595+/-10 990, P=0.02). The C/E ratio for stenting compared with PTCA was $10 550 per repeat revascularization avoided. In analyses that incorporated recent changes in stent technology and pricing, the 1-year cost differential fell to <$350/patient, and the C/E ratio improved to $3753 per repeat revascularization avoided. The cost-utility ratio for primary stenting was <$50 000 per quality-adjusted life year gained only if stenting did not increase 1-year mortality by >0.2% compared with PTCA. CONCLUSIONS: As performed in Stent-PAMI, primary stenting for AMI increased 1-year medical care costs compared with primary PTCA. The overall cost-effectiveness of primary stenting depends on the societal value attributed to avoidance of symptomatic restenosis, as well as on the relative mortality rates of primary PTCA and stenting.


Complete or incomplete percutaneous coronary revascularization in patients with unstable angina in stent era: Are early and one-year results different?

The aim of our study was to evaluate the impact of a strategy of incomplete revascularization by PTCA, with or without stent implantation, on clinical outcome of 208 consecutive patients (171 men) with unstable angina and multivessel coronary artery disease. Mean age of the group was 63.8 +/- 10.3 years (range, 31-91). Complete and incomplete revascularization was achieved in 49 and 159 patients, respectively. A total of 226 stents were implanted in 172 patients (1.31 +/- 0.65 stent per patient), equally distributed between the two groups. Left ventricular ejection fraction < 40% and total chronic coronary occlusions were significantly more frequent in patients with incomplete revascularization than in those with complete (P = 0.014 and 0.001, respectively). In-hospital MACE occurred in 10% and 7.5% of patients with complete and incomplete revascularization, respectively (P = NS). By multivariate analysis, multiple stent implantation (OR, 5.44; 95% CI, 1.21-24.3), presence of thrombus in the treated lesion (OR, 6.3; 95% CI, 1.53-25.9), Braunwald class III (OR, 4.74; 95% CI, 1.08-20.8), and ad hoc PTCA (OR 4.51; 95% CI, 1.11-18.3) were significantly related to in-hospital outcome. At 1-year follow-up, 11.3% and 11.5% of patients with complete and incomplete revascularization, respectively, had MACE. In all patients, diabetes (OR, 3.40; 95% CI, 1.09-10.58) and presence of thrombus in the treated lesion (OR, 3.48; 95% CI, 1.12-10.84) were significant predictors of 1-year outcome by multivariate analysis. These results indicate that the strategy of incomplete revascularization in unstable angina patients with multivessel coronary disease does not expose them to a higher risk of death or other major ischemic events in comparison to those undergoing complete revascularization.

Am Coll Cardiol 2001 Dec;38(7):2006-12

Statin therapy, inflammation and recurrent coronary events in patients following coronary stent implantation.


OBJECTIVES: We sought to investigate whether statin therapy affects the association between preprocedural C-reactive protein (CRP) levels and the risk for recurrent coronary events in patients undergoing coronary stent implantation. BACKGROUND: Low-grade inflammation as detected by elevated CRP levels predicts the risk of recurrent coronary events. The effect of inflammation on coronary risk may be attenuated by statin therapy. METHODS: We investigated a potential interrelation among statin therapy, serum evidence of inflammation, and the risk for recurrent coronary events in 388 consecutive patients undergoing coronary stent implantation. Patients were grouped according to the median CRP level (0.6 mg/dl) and to the presence of statin therapy.
RESULTS: A primary combined end point event occurred significantly more frequently in patients with elevated CRP levels without statin therapy (RR [relative risk] 2.37, 95% CI [confidence interval] [1.3 to 4.2]). Importantly, in the presence of statin therapy, the RR for recurrent events was significantly reduced in the patients with elevated CRP levels (RR 1.27 [0.7 to 2.1]) to about the same degree as in patients with CRP levels below 0.6 mg/dl and who did not receive statin therapy (RR 1.1 [0.8 to 1.3]). CONCLUSIONS: Statin therapy significantly attenuates the increased risk for major adverse cardiac events in patients with elevated CRP levels undergoing coronary stent implantation, suggesting that statin therapy interferes with the detrimental effects of inflammation on accelerated atherosclerotic disease progression following coronary stenting.

Am Heart J 2001 Dec;142(6):960-4

Coronary stenting in diabetic patients: Results from the ROSETTA registry.


OBJECTIVE: Diabetes mellitus is associated with high rates of restenosis and adverse outcomes after percutaneous transluminal coronary angioplasty (PTCA). It is unclear whether coronary stenting reduces adverse events in diabetic patients after PTCA. Our purpose was to determine whether coronary stenting improves clinical event rates in diabetic patients after PTCA. METHODS: The Routine Versus Selective Exercise Treadmill Testing After Angioplasty (ROSETTA) registry was a prospective multicenter observational study examining functional testing and adverse outcomes after successful PTCA. RESULTS: Among the 791 patients enrolled, 180 were diabetic. A total of 90 diabetics received stents while the remaining 90 patients did not. Baseline clinical characteristics were similar between the 2 groups of patients. However, patients with stents were more likely to have complex lesions, whereas those without stents were more likely to undergo atherectomy and have greater residual coronary stenosis. At 6-month follow-up, the composite end point defined as cardiac death, unstable angina, myocardial infarction, need for repeat PTCA, or coronary artery bypass graft surgery (CABG) occurred in 25.0% of stented and 22.2% of nonstented diabetic patients (P not significant [NS]). A multivariate logistic regression analysis showed that coronary stenting was not associated with a reduced incidence of the composite end point among diabetic patients (odds ratio 0.97, 95% CI 0.46-2.05, P NS). CONCLUSION: Coronary stenting does not improve clinical event rates in diabetic patients after PTCA.
A randomized comparison of direct stenting with conventional stent implantation in selected patients with acute myocardial infarction.

Loubeyre C, Morice MC, Lefevre T, Piechaud JF, Louvard Y, Dumas P.

OBJECTIVES: We sought to determine whether direct stenting might prevent the adverse events associated with stent implantation during primary angioplasty and to compare it with conventional stent implantation in patients with acute myocardial infarction (AMI). BACKGROUND: No trial has demonstrated that stents favorably influence mortality rate. Recent studies have even suggested a negative impact of stents on coronary blood flow and clinical outcome. METHODS: Of 409 patients treated by primary angioplasty with stent implantation in our center, 206 (50%) were enrolled in this randomized, single-center trial and allocated to direct stent implantation (n = 102) or stent implantation after balloon pre-dilation (n = 104). The study end points included angiographic results (final corrected Thrombolysis In Myocardial Infarction [TIMI] frame count and a composite end point of slow and no-reflow or distal embolization), an electrocardiogram marker of myocardial reperfusion assessment (ST-segment resolution) and in-hospital clinical outcome (death and recurrent infarction). RESULTS: Direct stent implantation failed in eight patients but succeeded after pre-dilation in all. A non-significant increase in TIMI flow grade 3 was achieved after direct stenting (95.1% vs. 93.3%, p = 0.74) without significant difference in the corrected TIMI frame count (31.5 +/- 17 and 35.2 +/- 20 frames after direct and conventional stent, respectively, p = 0.42). The composite angiographic end point was significantly reduced by direct stent implantation (11.7% vs. 26.9%, p = 0.01). ST-segment resolution was also significantly improved after direct stent (no ST-segment resolution in 20.2% vs. 38.1% after direct and conventional stent, respectively, p = 0.01). Death and/or recurrent infarction occurred in six patients after conventional stent implantation and in two patients after direct stenting (p = 0.28). CONCLUSIONS: In selected patients with AMI, direct stenting can be applied safely and effectively. This strategy may result in a significant reduction of microvascular injury, as suggested by improved ST-segment resolution after reperfusion with major potential clinical consequences.
Coronary in-stent restenosis: current status and future strategies.

Lowe HC, Oesterle SN, Khachigian LM.

In-stent restenosis (ISR) is a novel pathobiologic process, histologically distinct from restenosis after balloon angioplasty and comprised largely of neointima formation. As percutaneous coronary intervention increasingly involves the use of stents, ISR is also becoming correspondingly more frequent. In this review, we examine the available studies of the histology and pathogenesis of ISR, with particular reference to porcine and other animal models. An overview of mechanical treatments is then provided, which includes PTCA, directional coronary atherectomy and high speed rotational atherectomy. Radiation-based therapies are discussed, including a summary of current problems associated with this modality of treatment. Finally, novel strategies for the prevention of ISR are addressed, including novel developments in stents and stent coatings, conventional drugs, nucleic acid-based drugs and gene transfer. Until recently, limited pharmacologic and mechanical treatment options have been available for both treatment and prevention of ISR. However, recent advances in gene modification and gene transfer therapies and, more particularly, in local stent-based drug delivery systems make it conceivable that the incidence of ISR will now be seriously challenged.
for the prevention of ISR are addressed, including novel developments in stents and stent coatings, conventional drugs, nucleic acid-based drugs and gene transfer. Until recently, limited pharmacologic and mechanical treatment options have been available for both treatment and prevention of ISR. However, recent advances in gene modification and gene transfer therapies and, more particularly, in local stent-based drug delivery systems make it conceivable that the incidence of ISR will now be seriously challenged.

Lancet 2002 Feb 16;359(9306):551-7

Use of localised intracoronary beta radiation in treatment of in-stent restenosis: the INHIBIT randomised controlled trial.


BACKGROUND: In-stent restenosis is a major limitation of intracoronary stenting. Ionising gamma radiation has been shown to reduce recurrence of restenosis after stent placement. We aimed to compare the effects of intracoronary beta radiation treatment with those of placebo for clinical and angiographic outcomes of patients with diffuse in-stent restenosis. METHODS: 332 patients with in-stent restenosis underwent successful coronary intervention, and were then randomly allocated to intracoronary beta radiation with a phosphorus-32 source (n=166) or placebo (166) delivered into a centring balloon catheter through an automatic afterloader. Longer lesions (>22 mm of dilated length) were treated with tandem positioning of the study wire. The primary safety endpoint was major adverse cardiac events, defined as death, myocardial infarction, and repeat target-lesion revascularisation at 9 months. The primary efficacy endpoint was binary angiographic restenosis rate in the analysis segment during 9-months follow-up. Analysis was by intention to treat. FINDINGS: Procedural success, and in-hospital and 30-day complications were similar among the two groups. 24 (15%) patients in the radiated group had the primary safety endpoint of death, myocardial infarction, or repeat target-lesion revascularisation over 290 days compared with 15 (31%) in the placebo group (difference 16% [95% CI 7.5], p = 0.0006). Binary angiographic restenosis rate was lower in the radiated group than the placebo group for the entire analysed segment (difference 25% [14.7], p < 0.0001). INTERPRETATION: Vascular brachytherapy using pure beta-emitter 32P delivered into a centring catheter via an automatic afterloader can be used to reduce overall revascularisation in patients undergoing treatment for diffuse in-stent restenosis.
The effect of completeness of revascularization on event-free survival at one year in the ARTS trial.


We sought to assess the relationship between completeness of revascularization and adverse events at one year in the ARTS (Arterial Revascularization Therapies Study) trial. There is uncertainty to what extent degree of completeness of revascularization, using up-to-date techniques, influences medium-term outcome. After consensus between surgeon and cardiologist regarding the potential for equivalence in the completeness of revascularization, 1,205 patients with multivessel disease were randomly assigned to either bypass surgery or stent implantation. All baseline and procedural angiograms and surgical case-record forms were centrally assessed for completeness of revascularization. Of 1,205 patients randomized, 1,172 underwent the assigned treatment. Complete data for review were available in 1,143 patients (97.5%). Complete revascularization was achieved in 84.1% of the surgically treated patients and 70.5% of the angioplasty patients (p < 0.001). After one year, the stented angioplasty patients with incomplete revascularization showed a significantly lower event-free survival than stented patients with complete revascularization (i.e., freedom from death, myocardial infarction, cerebrovascular accident and repeat revascularization) (69.4% vs. 76.6%; p < 0.05). This difference was due to a higher incidence of subsequent bypass procedures (10.0% vs. 2.0%; p < 0.05). Conversely, at one year, bypass surgery patients with incomplete revascularization showed only a marginally lower event-free survival rate than those with complete revascularization (87.8% vs. 89.9%). Complete revascularization was more frequently accomplished by bypass surgery than by stent implantation. One year after bypass, there was no significant difference in event-free survival between surgically treated patients with complete revascularization and those with incomplete revascularization, but patients randomized to stenting with incomplete revascularization had a greater need for subsequent bypass surgery.

Early and sustained survival benefit associated with statin therapy at the time of percutaneous coronary intervention.
BACKGROUND: Long-term administration of statin therapy has been shown to reduce major coronary events and cardiac mortality within randomized clinical trials. In addition to lowering lipids, statins favorably affect platelet adhesion, thrombosis, endothelial function, inflammation, and plaque stability, which may potentially improve outcome after percutaneous coronary intervention (PCI). Therefore, we hypothesized that statin therapy has an early beneficial effect among patients undergoing PCI. METHODS AND RESULTS: Each year from 1993 to 1999, we prospectively collected data among the first 1000 patients undergoing PCI. Patients who presented with acute or recent myocardial infarction or cardiogenic shock were excluded from the analysis. Baseline, procedural, and 6-month data of statin-treated and non-statin-treated patients were compared. Propensity score and multivariate survival analysis were used to adjust for heterogeneity between the two groups. Of 5052 patients who completed follow-up, 26.5% were treated with statin at the time of the procedure. Statin therapy was associated with a mortality reduction at 30 days (0.8% versus 1.5%; hazard ratio, 0.53; P=0.048) and at 6 months (2.4% versus 3.6%; hazard ratio, 0.67; P=0.046). After adjusting for the propensity to receive statin therapy before the procedure and other confounders, statin therapy remained an independent predictor for survival at 6 months after coronary intervention (hazard ratio, 0.65; 95% CI, 0.42 to 0.99; P=0.045). CONCLUSIONS: In this large study cohort, statin therapy among PCI patients seems to be associated with a significant mortality advantage at early and intermediate-term follow-up.

JAMA 2002 Feb 6;287(5):618-21

Long-term efficacy of platelet glycoprotein IIb/IIIa integrin blockade with eptifibatide in coronary stent intervention.


CONTEXT: In the Enhanced Suppression of the Platelet IIb/IIIa Receptor with Integrilin Therapy (ESPRIT) trial, treatment with eptifibatide, a platelet glycoprotein IIb/IIIa integrin blocker, was found to reduce the ischemic
complications of nonurgent coronary stent implantation at 48 hours and 30 days. OBJECTIVE: To determine whether eptifibatide treatment continues to provide durable, long-term benefit after coronary stent intervention. DESIGN AND SETTING: The ESPRIT trial was a randomized, double-blind, placebo-controlled, parallel-group, crossover-permitted trial conducted from June 1999 through February 2000 at 92 tertiary care centers in the United States and Canada. PARTICIPANTS: A total of 2064 patients scheduled to undergo nonurgent percutaneous coronary intervention with stent implantation. INTERVENTION: Patients were randomly assigned to receive placebo (n = 1024) or eptifibatide (two 180-microg/kg boluses, 10 minutes apart, with a continuous infusion of 2.0 microg/kg per minute; n = 1040), started immediately before stent implantation and continued for 18 to 24 hours. Patients also received aspirin, heparin, and a thienopyridine. MAIN OUTCOME MEASURES: Composite rates of death or myocardial infarction (MI) and death, infarction, or target vessel revascularization during the 12 months after enrollment. RESULTS: Complete follow-up data were available for 988 patients given eptifibatide (95.0%) and 976 patients given placebo (95.3%). By 12 months, the composite of death or MI had occurred in 8.0% of eptifibatide-treated patients and in 12.4% of placebo-treated patients (hazard ratio [HR], 0.63; 95% confidence interval [CI], 0.48-0.83; P =.001). The composite rate of death, MI, or target vessel revascularization was 17.5% in eptifibatide-treated patients vs 22.1% in placebo-treated patients (HR, 0.76; 95% CI, 0.63-0.93; P =.007). CONCLUSIONS: Long-term outcomes of nonurgent coronary stent implantation appear to be improved through blockade of the platelet glycoprotein IIb/IIIa integrin with eptifibatide.

J Am Coll Cardiol 2002 Feb 6;39(3):393-9

A randomized comparison of the value of additional stenting after optimal balloon angioplasty for long coronary lesions: final results of the additional value of NIR stents for treatment of long coronary lesions (ADVANCE) study.


OBJECTIVES: We sought to investigate the clinical benefit of additional stent implantation after achieving an optimal result of balloon angioplasty (BA) in long coronary lesions (>20 mm). BACKGROUND: Long coronary lesions are associated with increased early complications and late restenosis after BA. Stenting improves the early outcome, but stent restenosis is also related to both lesion length and stent length. METHODS: A total of
437 patients with a single native lesion 20 to 50 mm in length were included and underwent BA, using long balloons matched to lesion length and vessel diameter (balloon/artery ratio 1.1) to achieve a diameter stenosis (DS) <30% by on-line quantitative coronary angiography (QCA). Bail-out stenting was performed for flow-limiting dissections or >50% DS. Patients in whom an optimal BA result was achieved were randomized to additional stenting (using NIR stents) or no stenting. The primary end point was freedom from major adverse cardiac events (MACE) at nine months, and core laboratory QCA was performed on serial angiograms. RESULTS: Bail-out stenting was necessary in 149 patients (34%) and was associated with a significantly increased risk of peri-procedural infarction (p < 0.02). Among the 288 randomized patients, the mean lesion length was 27+/-9 mm, and the vessel diameter was 2.78+/-0.52 mm. The procedural success rate was 90% for the 143 patients assigned to BA alone (control group), as compared with 93% in the 145 patients assigned to additional stenting (stent group), which resulted in a superior early minimal lumen diameter (0.54 mm, p < 0.001) and led to reduced angiographic restenosis (27% vs. 42%, p = 0.022). Freedom from MACE at nine months was 77% in both groups. CONCLUSIONS: A strategy of provisional stenting for long coronary lesions led to bailout stenting in one-third of patients, with a threefold increase in peri-procedural infarction. Additional stenting yielded a lower angiographic restenosis rate, but no reduction in MACE at nine months.

J Am Coll Cardiol 1993;22:1641-6

Fate of Lesion-Related Side Branched After Coronary Artery Stenting

David L. Fischman, MD, Michael P. Savage, MD, FACC, Martin B. Leon, MD, FACC, Richard A Schatz, MD, FACC, Stephen Ellis, MD, FACC, Michael W. Cleman, MD, FACC, John W. Hirshfield, MD, FACC, Paul Teirstein, MD, FACC, Steven Bailey, MD, FACC, Craig M. Walker, MD, FACC, Sheldon Goldberg, MD, FACC

Objectives. The aim of this study was to assess the immediate and long-term patency of lesion-associated side branched after coronary artery stenting.

Background. The possible adverse effects related to implantation of coronary stents are not completely known. An important potential complication of stenting is side branch occlusion due to mechanical obstruction or thrombosis.

Methods. Serial coronary angiography was performed in 153 patients (167 lesions) at baseline, after conventional balloon angioplasty, immediately after Palmaz-Schatz stent placement and at 6 months. The patency of side branches, where present, was analyzed at each of these points.
Results. Of 167 lesions stented, 57 stent placements spanned 66 side branches with a diameter ≥1 mm. Twenty-seven (41%) of these side branches had ≥50% ostial stenosis before standard balloon angioplasty. Six side branches became occluded after standard balloon angioplasty and remained occluded after stenting. Of the 60 side branches patent after conventional angioplasty, 57 (95%) remained patent immediately after stenting. All three side branches that became occluded after stenting had ≥50% ostial stenosis at baseline. All 60 side branches, including the 3 initially occluded after stenting, were patent at 6-month follow-up.

Conclusion. These findings demonstrate that 1) acute side branch occlusion due to coronary stenting occurs infrequently; 2) when side branch occlusion occurs, it is associated with intrinsic ostial disease; and 3) the patency of side branch ostia is well maintained at long-term follow-up.

Summary
1. Six of the 66 side branches: occluded after balloon angioplasty and remained occluded after stenting.
2. Of the 60 side branches patent after conventional angioplasty, 57 (95%) remained patent immediately after stenting.
3. All 60 side branches: patent at 6-month follow-up.

Circulation, Vol 85, 916-927

Intracoronary stenting for acute and threatened closure complicating percutaneous transluminal coronary angioplasty

GS Roubin, AD Cannon, SK Agrawal, PJ Macander, LS Dean, WA Baxley and J Breland
Division of Cardiovascular Disease, University of Alabama, Birmingham 35294.

BACKGROUND. Acute closure remains a significant limitation of percutaneous transluminal coronary angioplasty (PTCA) and underlies the majority of ischemic complications. This study details the clinical and angiographic characteristics of a series of patients receiving an intracoronary stent device to manage acute and threatened closure and presents the early clinical results.

METHODS AND RESULTS. From October 1989 through June 1991, 115 patients undergoing PTCA received intracoronary stents to treat acute or threatened closure in 119 vessels. Sixty-three percent had multivessel coronary disease, 33 (29%) had undergone prior coronary artery bypass grafting (CABG), and 52 (45%) had had previous PTCA. Using the American College of Cardiology/American Heart Association (ACC/AHA)
classification, 15% of lesions were class A, 55% were class B, and 30% were class C. Eight patients were referred with severe coronary dissection and unstable angina after PTCA at other institutions. Acute closure was defined as occlusion of the vessel with TIMI (Thrombolysis in Myocardial Infarction) 0 or 1 flow immediately before stent placement. Threatened closure required two or more of the following criteria: 1) a residual stenosis greater than 50%, 2) TIMI grade 2 flow, 3) angiographic dissection comprising extraluminal dye extravasation and/or a length of greater than 15 mm, 4) evidence of clinical ischemia (either typical angina or ECG changes). Twelve vessels (10%) met the criteria for acute closure, and 87 vessels (73%) satisfied the criteria for threatened closure. Twenty vessels (17%) failed to meet two criteria. Stenting produced optimal angiographic results in 111 vessels (93%), with mean diameter stenosis (+/- SD) reduced from 83 +/- 12% before to 18 +/- 29% after stenting. Overall, in-hospital mortality was 1.7% and CABG was required in 4.2%; Q wave myocardial infarction (MI) occurred in 7% and non-Q wave MI in 9%. Stent thrombosis occurred in nine patients (7.6%). For the 108 patients who presented to the catheterization laboratory without evolving MI, Q wave MI occurred in 4% and non-Q wave MI occurred in 7%. Angiographic follow-up has been performed in 81 eligible patients (76%), and 34 patients (41%) had a lesion of greater than or equal to 50%. CONCLUSIONS. This stent may be a useful adjunct to balloon dilatation in acute or threatened closure. Randomized studies comparing this stent with alternative technologies are required.

Summary
1. Optimal angiographic results after stenting: 93%, mean diameter stenosis reduced from 83 +/- 12% before to 18 +/- 29% after stenting.
2. In-hospital mortality - 1.7%, CABG - 4.2%; Q wave MI - 7% and non-Q MI - 9%.
3. Stent thrombosis: 7.6%
Restenosis: 41%


A Comparison of Balloon-Expandable-Stent Implantation with Balloon Angioplasty in Patients with Coronary Artery Disease

Patrick W. Serruys, Peter de Jaegere, Ferdinand Kiemeneij, Carlos Macaya, Wolfgang Rutsch, Guy Heyndrickx, Hakan Emanuelsson, Jean Marco, Victor Legrand, Pierre Materne, Jorge Belardi, Ulrich Sigwart, Antonio Colombo, Jean Jacques Goy, Paul van den Heuvel, Juan Delcan, Marie-angele Morel, for the Benestent Study Group

Abstract
Background. Balloon-expandable coronary-artery stents were developed to prevent coronary restenosis after coronary angioplasty. These devices hold coronary vessels open at sites that have been dilated. However, it is unknown whether stenting improves long-term angiographic and clinical outcomes as compared with standard balloon angioplasty.

Methods. A total of 520 patients with stable angina and a single coronary-artery lesion were randomly assigned to either stent implantation (262 patients) or standard balloon angioplasty (258 patients). The primary clinical end points were death, the occurrence of a cerebrovascular accident, myocardial infarction, the need for coronary-artery bypass surgery, or a second percutaneous intervention involving the previously treated lesion, either at the time of the initial procedure or during the subsequent seven months. The primary angiographic end point was the minimal luminal diameter at follow-up, as determined by quantitative coronary angiography.

Results. After exclusions, 52 patients in the stent group (20 percent) and 76 patients in the angioplasty group (30 percent) reached a primary clinical end point (relative risk, 0.68; 95 percent confidence interval, 0.50 to 0.92; P = 0.02). The difference in clinical-event rates was explained mainly by a reduced need for a second coronary angioplasty in the stent group (relative risk, 0.58; 95 percent confidence interval, 0.40 to 0.85; P = 0.005). The mean (±SD) minimal luminal diameters immediately after the procedure were 2.48±0.39 mm in the stent group and 2.05±0.33 mm in the angioplasty group; at follow-up, the diameters were 1.82±0.64 mm in the stent group and 1.73±0.55 mm in the angioplasty group (P = 0.09), which correspond to rates of restenosis (diameter of stenosis, greater than or equal to 50 percent) of 22 and 32 percent, respectively (P = 0.02). Peripheral vascular complications necessitating surgery, blood transfusion, or both were more frequent after stenting than after balloon angioplasty (13.5 vs. 3.1 percent, P<0.001). The mean hospital stay was significantly longer in the stent group than in the angioplasty group (8.5 vs. 3.1 days, P<0.001).

Conclusions. Over seven months of follow-up, the clinical and angiographic outcomes were better in patients who received a stent than in those who received standard coronary angioplasty. However, this benefit was achieved at the cost of a significantly higher risk of vascular complications at the access site and a longer hospital stay.

Summary

J Am Coll Cardiol 1995;26:720-4

Small Stent Size and Intimal Hyperplasia Contribute to Restenosis: A Volumetric Intravascular Ultrasound
Objectives. The purpose of this study was to use volumetric intravascular ultrasound analysis of Palmaz-Schatz stents to assess the in-stent restenotic process.

Background. By reducing lesion elastic chronic arterial remodeling, stent improve the long-term results of coronary angioplasty. However, stents are prone to the development of neointimal hyperplasia responses are the cause of in-stent restenosis; however, it is difficult to visualize the radiolucent Palmaz-Schatz stent by angiography. Intravascular ultrasound provides detailed cross-sectional imaging of the coronary arteries, especially the intense metallic reflection of endovascular stents.

Methods. Forty-four patients with 60 Palmaz-Schatz stents underwent intravascular ultrasound imaging at follow-up ([mean ± SD] 8.8±7.2 months after implantation). Thirty-four stents were placed in saphenous vein grafts and 26 in native coronary arteries; 30 were placed in restenosis lesions. Intravascular ultrasound with automatic transducer pullback at 0.5 mm/s allowed measurement of stent, lumen and intimal hyperplasia cross-sectional areas at 1-mm axial increments within the stents. Using Simpson’s rule, stent, lumen and intimal hyperplasia volumes were calculated. Patterns of in-stent restenosis were then identified.

Results. Restenotic stents had smaller volumes (120±41 vs. 147±43 mm3, p=0.016) and lumen volumes (62±28 vs. 118±42 mm3, p<0.001) but larger intimal hyperplasia volumes (58±36 vs. 29±18 mm3, p<0.001) than nonrestenotic stents. A focal restenosis pattern was more common (20[77%] of 26) than a diffuse restenosis pattern (6[23%] of 26). Stents with focal restenosis and stents with diffuse restenosis had equally small stent volumes (120±44 vs. 120 ± 31 mm3, respectively, p=NS); however, stents with diffuse restenosis had larger intimal hyperplasia volumes (84±30 vs. 50±34 mm3, p<0.05). Focal rest was most commonly located at the central articulation (45%); the location of focal restenosis was related to the focal accumulation of neointimal tissue.

Conclusion. Stent volume and magnitude and distribution of intimal hyperplasia are important in the development of in-stent restenosis. Stent volume was smaller and intimal hyperplasia volume greater in restenotic stents. Stent restenosis is more commonly focal in nature and located at the central articulation.

Focal restenosis - most commonly located at the central articulation (45%) and related to the focal accumulation of neointimal tissue.
Immediate Results and Late Outcomes After Stent Implantation in Saphenous Vein Graft Lesions: The Multicenter U.S. Palmaz-Schatz Stent Experience

S. Chiu Wong, MD, FACC, Donald S. Baim, MD, FACC, Richard A. Schatz, MD, FACC, Paul S. Teirstein, MD, FACC, Spencer B. King III, MD, FACC, R. Charles Curry, Jr., MD, FACC, Richard R. Heuser, MD, FACC, Stephen G. Ellis, MD, FACC, Michael W. Cleman, MD, FACC, Paul Overlie, MD, FACC, John W. Hirshfeld, MD, FACC, Craig M. Walker, MD, FACC, Frank Litvack, MD, FACC, David Fish, MD, FACC, Jeffrey A. Brinker, MD, FACC, Maurice Buchbinder, MD, FACC, Sheldon Goldberg, MD, FACC, Ya Chien Chuang, PhD, Martin B. Leon, MD, FACC, for the Palmaz-Schatz Stent Study Group

Objectives. This study reports the multicenter registry experience evaluating the safety and efficacy of the Palmaz-Schatz stent in the treatment of saphenous vein graft disease.

Background. Saphenous vein graft angioplasty is associated with frequent peri-procedural complications and a high frequency of restenosis. Stent implantation has been shown to reduce restenosis, with improved long-term outcomes in the treatment of native coronary artery disease. Preliminary experience with stent placement in the treatment of saphenous vein graft lesions has been favorable.

Methods. Twenty U.S. investigator sites enrolled a total of 589 symptomatic patients (624 lesions) for treatment of focal vein graft stenoses between January 1990 and April 1992. Follow-up angiography was performed at 6 months, and the clinical course of all study patients was prospectively collected at regular intervals for up to 12 months.

Results. Stent delivery was successful in 98.8% of cases, and the procedural success rate was 97.1%. The lesion diameter stenosis decreased from 82±12% (mean ± SD) before to 6.6±10.2% after treatment. Major in-hospital complications occurred in 17 patients (2.9%); stent thrombosis was found in 8 (1.4%); and major vascular or bleeding complications were noted in 83 (14.3%). Six-month angiographic follow-up revealed an overall restenosis rate (>50% diameter stenosis) of 29.7%. Multivariate logistic regression analysis indicated that 1) restenotic lesions, 2) smaller reference vessel size, 3) history of diabetes mellitus, and 4) higher percent poststent diameter stenosis were independent predictors of restenosis. The 12-month actuarial event-free survival was 76.3%.

Conclusion. Stent implantation in patients with focal saphenous vein graft lesions can be achieved with a high rate of procedural success, acceptable major complications, reduced angiographic restenosis and favorable late clinical outcome compared with historical balloon angioplasty control series. The rigorous anticoagulation
regimen after stent placement results in more frequent vascular and other bleeding complications. Future randomized studies comparing standard balloon angioplasty with stent implantation are warranted to properly assess the full impact of stent placement in the treatment of saphenous vein graft lesions.

Summary
1. Successful stent delivery: 98.8%, procedural success: 97.1%
2. Diameter stenosis: 82% to 6.6%
3. Major in-hospital complications: 2.9%
4. Major vascular or bleeding complications: 14.3%, stent thrombosis: 1.4%
5. Restenosis: 29.7%
6. The 12-month actuarial event-free survival was 76.3%.

J Am Cardiol 1995;75:26-29

Coronary Stenting for Treatment of Ostial Stenoses of Native Coronary Arteries or Aortocoronary Saphenous Vein Grafts

Krishna Rocha-Singh, MD, Nancy Morris, RN, S. Chiu Wong, MD, Richard A. Schatz, MD, and Paul S. Teirstein, MD

This study examines the procedural success, complication, and restenosis rates in patients undergoing Palmaz-Schatz stenting of native coronary and saphenous vein graft ostial stenoses. All patients undergoing Palmaz-Schatz stent placement of ostial lesions (≥70% diameter stenosis within 3 mm from the arterial ostium) between November 1989 and February 1992 were included in this study. Patients were treated with aspirin, dipyridamole, low molecular weight dextran, and heparin during the procedure and received systemic anticoagulation with warfarin for 1 month after the procedure. Angiographic measurements were obtained using electronic calipers. Coronary stents ostial stenosis was in a saphenous vein graft in 54% and a native coronary artery in 46% of lesions. The mean pre- and postprocedural minimal luminal diameters were 0.8 ± 0.7 and 3.3 ± 0.8 mm, respectively (p<0.0001), corresponding to a mean diameter stenosis of 83.5 ± 10.0% and 1.0 ± 4.2%. Two patients had subacute stent thrombosis related to premature discontinuation of antithrombotic medications. Two patients died, 1 because of stent thrombosis and 1 because of progressive renal failure and sepsis. Angiographic follow-up was obtained at a mean of 5.8 ± 1.8 months in 95% of patients with a successful stent procedure. The overall restenosis rate (>50% diameter stenosis at follow-up)
was 27.8%. Thus, stenting of ostial native coronary and vein graft stenoses can be performed with excellent angiographic and procedural success rates. Restenosis rates appear to be lower than expected using historical control subjects. The effectiveness of stenting for these patients, however, may be limited by significant procedural complications.

Summary
1. Mean preprocedural MLD 0.8mm, mean postprocedural MLD 3.3mm(p<0.0001)
2. Subacute stent thrombosis: 2 patients with premature discontinuation of antithrombotic medications.
3. Death: 2 patients(1 because of stent thrombosis and 1 progressive renal failure and sepsis)
Restenosis: 27.8%.

J Am Coll Cardiol 1996;27:255-61

Clinical Studies
Continued Benefit of Coronary Stenting Versus Balloon Angioplasty: One-Year Clinical Follow-Up of Benestent Trial

Carlos Macaya, MD, Patrick W. Serruys, MD, FACC, Peter Ruygrok, MD, Harry Suryapranata, MD, Gijs Mast, MD, Silvio Klugmann, MD, Philippe Urban, MD, Peter den Heijer, MD, Karel Koch, MD, Rudiger Simon, MD, Marie-Claud Morice, MD, Peter Crean, MD, Hans Bonnier, MD, William Wijns, MD, Nicolas Danchin, MD, Claud Bourdonnec, MD, Marie-Angele Morel, Msc, for the BENESTENT Study Group

Objectives. This study sought to determine the 1-year clinical follow-up of patients included in the Benestent trial.

Background. The Benestent trial is a randomized study comparing elective Palmaz-Schatz stent implantation with balloon angioplasty in patients with stable angina and a de novo coronary artery lesion. Seven-month follow-up data have shown a decreased rate of restenosis and fewer clinical events in the stent group. It is not established whether this favorable clinical outcome is maintained for longer periods or whether coronary stenting defers restenosis and its subsequent clinical manifestations.

Methods. To clarify this uncertainty, we updated clinical information on all but 1 of 516 patients enrolled in the Benestent trial (257 in balloon group, 259 in stent group) at least 12 months after the intervention. Major clinical events (primary clinical end point) were tabulated according to the intention to treat principle and included
death, the occurrence of a cerebrovascular accident, myocardial infarction, the need for bypass surgery or a further percutaneous intervention in the previously treated lesion.

Results. After 1 year, no significant differences in mortality (1.2% vs. 0.8%), stroke (0.0% vs. 0.8%), myocardial infarction (5.0% vs. 4.2%) or coronary bypass surgery (6.9% vs 5.1%) were found between the stent and balloon angioplasty groups, respectively. However, the requirement for a repeat angioplasty procedure was significantly lower in the stent group (10%) than the balloon angioplasty group (21%, relative risk [RR] 0.49, 95% confidence interval [CI] 0.31 to 0.75, p=0.001), and overall primary end point were less frequently reached by stent group patients (23.2%) than those in the balloon group (31%, RR 0.74, 95% CI 0.55 to 0.98, p=0.04). No differences were found between groups with respect to functional class angina and prescribed medication at the time of follow-up.

Conclusion. These clinical follow-up data show that the benefit of elective native coronary artery stenting in patients with stable angina is maintained to at least 1 year after the procedure and results in a significantly reduced requirement for repeat intervention.

Summary


Three-Year Follow-Up after Implantation of Metallic Coronary-Artery Stents

Takeshi Kimura, Hiroyoshi Yokoi, Yoshihisa Nakagawa, Takashi Tamura, Satoshi Kaburagi, Yoshihiro Sawada, Yasukazu Sato, Hiroatsu Yokoi, Naoya Hamasaki, Hideyuki Nosaka, Masakiyo Nobuyoshi

Background. Coronary-artery stents are known to reduce rates of restenosis after coronary angioplasty, but it is uncertain how long this benefit is maintained.

Methods. We evaluated clinical and angiographic follow-up information for up to three years after the implantation of Palmaz-Schatz metallic coronary-artery stents in 143 patients with 147 lesions of native coronary arteries.

Results. The rate of survival free of myocardial infarction, bypass surgery, and repeated coronary angioplasty for stented lesions was 74.6 percent at three years. After 14 months, revascularization of the stented lesion was necessary in only three patients (2.1 percent). In contrast, coronary angioplasty for a new lesion was required in 11 patients (7.7 percent). Follow-up coronary angiography of 137 lesions at six months, 114 lesions at one year, and 72 lesions at three years revealed a decrease in minimal luminal diameter from 2.54±0.44 mm immediately after stent implantation to 1.87±0.56 mm at six months, but no further decrease in diameter at one year (in patients with paired angiograms, 1.95±0.49 mm at both six months and one year). Significant late improvement
in luminal diameter was observed at three years (in patients with paired angiograms, 1.94±0.48 mm at six months and 2.09±0.48 mm at three years; P<0.001).

Conclusions. Clinical and angiographic outcomes up to three years after coronary-artery stenting were favorable, with a low rate of revascularization of the stented lesions. Late improvement in luminal diameter appears to occur between six months and three years.

Summary
1. Survival free of myocardial infarction, bypass surgery, and repeated coronary angioplasty for stented lesions: 74.6 percent at three years.
2. TLR after 14 months: three patients (2.1 percent).
3. Angioplasty for a new lesion: 11 patients (7.7 percent).

Significant late improvement in luminal diameter was observed at three years (in patients with paired angiograms, 1.94±0.48 mm at six months and 2.09±0.48 mm at three years; P<0.001).

The American Journal of Cardiology, 80:8:994-997

Incidence and Angiographic Predictors of Side Branch Occlusion Following High-Pressure Intracoronary Stenting

Darius Aliabadi, MD, Frank V. Tilli, MD, Terry R. Bowers, MD, Keith H. Benzuly, MD, Robert D. Safian, MD, James A. Goldstein, MD, Cindy L. Grines, MD, William W. O’Neill, MD

We evaluated the incidence, angiographic predictors, and clinical outcome of side branch occlusion (SBO) following high-pressure intracoronary stenting in 175 patients. All stent implants during a 7-month period were reviewed for the incidence of major (>1 mm) SBO. Side branches were further characterized based on side branch and index lesion morphology. Clinical events (death, myocardial infarction, and target vessel revascularization rates) were determined at 9 months. A total of 175 patients (182 lesions) had 224 major side branches covered by intracoronary stents. Of these, 43 (19%) occluded. Most SBOs (29 of 43 [67%]) occurred after poststent dilation using high-pressure inflations (15.3 ± 3.3 atmospheres). No clinical characteristics correlated with SBO. By multivariate analysis, those side branches with >50% ostial narrowing that arose from within or just beyond the diseased portion of the parent vessel (threatened side branch morphologies) were a powerful angiographic predictor of SBO (odds ratio 40, 95% confidence interval, 14 to 130, p <0.0001). At 9-month follow-up there was no difference in combined clinical events between those patients with and without
SBO. These data demonstrate that side branches with ostial stenoses in continuity with diseased parent lesions were at risk of occlusion following stenting. SBO, however, was not associated with adverse clinical outcome. These findings lend support to plaque shift (now plow effect) as the mechanism behind SBO following stent placement.


Restenosis Rates in Diabetic Patients: A Comparison of Coronary Stenting and Balloon Angioplasty in Native Coronary Vessels

Eric Van Belle, Christophe Bauters, Edouard Hubert, Jean-Christophe Bodart, Kaveh Abolmaali, Thibaud Meurice, Eugene P. McFadden, Jean-Marc Lablanche, and Michel E. Bertrand

Background Diabetes is a major risk factor for restenosis after coronary balloon angioplasty. Recent studies have shown that coronary stenting significantly reduces restenosis compared with balloon angioplasty alone. However, limited information is available on the effect of coronary stenting in diabetic patients.

Methods and Results We designed this study to analyze the effect of diabetes on restenosis in patients treated with either balloon angioplasty or coronary stenting who were enrolled in a 6-month angiographic follow-up program. Three hundred consecutive patients, 19% of whom were diabetics, who underwent coronary stent implantation during a single-vessel procedure on native coronary vessels and who had 6-month angiographic follow-up constituted the study group (stent group). Three hundred consecutive patients who underwent 6-month angiographic follow-up after single-vessel conventional balloon angioplasty served as control patients (balloon group). Preprocedural, postprocedural, and follow-up angiograms were analyzed with quantitative angiography. In the balloon group, the restenosis rate was almost twofold higher in diabetic than in nondiabetic patients (63% versus 36%; P=.0002) owing to both a greater late loss (0.79±0.70 versus 0.41±0.61 mm, respectively; P<.0001) and a higher rate of late vessel occlusion (14% versus 3%, respectively; P<.001). In the stent group, restenosis rates were similar in diabetics and nondiabetics (25% versus 27%, respectively). Furthermore, in the stent group, late loss (0.77±0.65 versus 0.79±0.57 mm, respectively) and the rate of late vessel occlusion (2% versus 1%, respectively) did not differ significantly between diabetic and nondiabetic patients.

Conclusions Although diabetics have increased rates of restenosis and late vessel occlusion after simple balloon angioplasty, they have the same improved outcome with coronary stenting that has been documented in
The long-term effects of intracoronary stents in human are unknown. This is the first 9-year follow-up report of single-vessel-disease patients treated with the Palmaz-Schatz stent. Between March and December 1989, out of the 107 patients undergoing Palmaz-Schatz stent implantation, 71 (66%) had single-vessel disease. The average age of these patients was 58 ± 9 years and 79% were men. At 9 years, follow-up was obtained for 90.1% and major adverse clinical events consisted of 4 deaths giving a global survival rate of 95.8%, 7 myocardial infarction, 3 bypass surgeries, and 16 repeat percutaneous revascularization procedures. The 9-year event-free survival rate was 60%, and 81.7% of the patients were free from death, myocardial infarction, and bypass surgery. Multivariate analysis showed that the only predictive factor of major adverse clinical events was the presence of diabetes mellitus (P < 0.004).

The American Journal of Cardiology, 80:6:711-715

Comparison of Outcome After Stenting for De Novo Versus Restenotic Narrowings in Native Coronary Arteries

Suneet Mittal, MD, Debra L. Weiss, RN, MSN, John W. Hirshfeld, Jr., MD, Daniel M. Kolansky, MD, Howard C. Herrmann, MD

Intracoronary stenting of de novo narrowings results in a lower restenosis rate when compared with percutaneous transluminal coronary angioplasty. We sought to determine whether intracoronary stenting for restenotic narrowings is associated with a worse outcome when compared with stenting for de novo narrowings. A total of 114 consecutive patients with 124 narrowings were retrospectively identified. Stents were deployed in 46 de novo (37%) and in 78 restenotic (63%) narrowings. The 2 groups were similar with
respect to variables known to affect restenosis. Follow-up angiograms were available in 88% of patients at a mean of 6.3 ± 3.3 months after stent implantation. At follow-up angiography, a significantly higher restenosis rate in the restenotic group was observed (p = 0.05). Restenosis risk could not be predicted from variables known at the time of stent implantation. However, the presence of angina at the time of follow-up was significantly associated with restenosis (p = 0.01). Kaplan-Meier survival curves for freedom from repeat target-site revascularization demonstrated a significant difference in the need for target-site revascularization between the de novo and restenotic groups over the first-year post-stent implantation (p = 0.01; relative risk = 1.94). Multivariate analysis identified restenosis as the indication for stenting (p < 0.01), postprocedure percent stenosis (p = 0.01), and narrowing length (p = 0.01) as independent predictors for repeat target-site revascularization. When compared with de novo narrowings, restenotic narrowings have a worse outcome after stenting. A prospective, randomized trial comparing outcome after percutaneous transluminal coronary angioplasty and stents for restenotic narrowings would be useful.

Journal of the American College of Cardiology, 29:2:323-327

Outpatient Coronary Stent Implantation

Ferdinand Kiemeneij, MD, PhD, Gert Jan Laarman, MD, PhD, Ton Slagboom, MD, Ron van der Wieken, MD

Objectives. This study was performed to explore the feasibility of coronary Palmaz-Schatz stent implantation on an outpatient basis.

Background. To optimize the applicability of coronary stenting by limiting bleeding complications and length of hospital stay, the transradial approach has been demonstrated to be an effective technique. Immediate ambulation opens the way to outpatient treatment.

Methods. Patients selected for Palmaz-Schatz stent implantation received anticoagulation with Coumadin. At an international normalized ratio >2.5, stenting was performed through the radial approach. Starting in December 1994, patients were treated with Ticlopidin. Heparin was administered during the procedure. Suitability for same-day discharge was assessed on the basis of preprocedural, postprocedural and periprocedural criteria. Patients were mobilized after immediate sheath removal, followed by same-day discharge. Follow-up examinations were performed the next day, at 2 weeks and at 1 month after stenting.

Results. Of 188 patients who underwent Palmaz-Schatz coronary stent implantation through the radial artery between May 1994 and July 1995, 88 remained in the hospital for various reasons. In the 100 outpatients
(Canadian Cardiovascular Society classes III and IV, n = 90 [90%]), 125 stents had been implanted to cover 110 lesions. No cardiac or bleeding events were encountered within 24 h (95% confidence interval 0 to 3.6) of stenting. At 2-week follow-up, one patient was readmitted (day 4) because of a bleeding abdominal aortic aneurysm requiring operation. Two patients were readmitted 2 weeks after discharge, one with subacute thrombosis and one with angina and anemia that was treated with blood transfusions. At 1-month follow-up, no complications were observed.

Conclusions. After an optimal transradial Palmaz-Schatz coronary stent result, patients can safely be discharged on the day of treatment.

Journal of the American College of Cardiology, 30:1:180-185

Multivessel Palmaz-Schatz Stenting: Early Results and One-Year Outcome

Roger J. Laham, MD, Kalon K. L. Ho, MD, MSc, FACC, Donald S. Baim, MD, FACC, Richard E. Kuntz, MD, MSc, FACC, David J. Cohen, MD, MSc, Joseph P. Carrozza, MD, FACC, Jr.

Objectives. To determine whether the benefits outlined in Background might extend to patients with multivessel disease, we examined the short- and long-term outcome of multivessel Palmaz-Schatz stenting.

Background. Percutaneous transluminal coronary angioplasty (PTCA) has become the dominant treatment for most patients with single-vessel coronary artery disease and has emerged as an alternative treatment for selected patients with multivessel coronary artery disease. Although multivessel angioplasty has excellent early results and low procedural complication rates, long-term outcome is tempered by the frequent need for repeat revascularization. In patients with single-vessel coronary artery disease, Palmaz-Schatz stenting has been shown to have a higher success rate and a lower restenosis rate than conventional PTCA.

Methods. A total of 103 patients (mean age 64 ± 11 years, 78 men and 25 women) underwent stenting of 212 vessels (saphenous vein graft [53%], left anterior descending coronary artery [20%], left circumflex artery [12%] and right coronary artery [15%]). In 88 patients (85%), multivessel stenting was performed during the same procedure, whereas the remaining 15 patients (15%) had staged multivessel stenting within 1 week of the index stent. Stenting involved only native coronary arteries in 33 patients and only vein grafts in 51 patients.

Results. Angiographic success was achieved in 102 patients (99%). Major complications developed in three patients: one patient died, and two patients had Q wave myocardial infarction, with no emergency coronary
artery bypass graft surgery or stent thrombosis. Eleven additional patients (11%) developed non-Q wave myocardial infarction, and nine patients (9%) had local vascular complications requiring surgical repair. Clinical follow-up was available in all patients at a mean of 13 ± 8 months. At 1 year, survival was 98%, with an event-free survival rate of 80%, reflecting predominantly repeat revascularization (17% overall, with 9% target site revascularization). Multivessel native coronary stenting resulted in a higher event-free survival rate and a lower probability of repeat revascularization than did multivessel saphenous vein graft stenting.

Conclusions. In selected patients, multivessel Palmaz-Schatz stenting is technically feasible and carries both excellent early results and favorable 1-year clinical outcome.

The American Journal of Cardiology, 1997;80:9:1155-

Acute and 30-Day Results of the Serpentine Balloon Expandable Stent Implantation in Simple and Complex Coronary Arterial Narrowings

Ariel Roguin, MD, Ehud Grenadier, MD, Benjamin Peled, MD, Walter Markiewicz, MD, Rafael Beyar, MD, DSc

We report the acute and 30-day results with a new serpentine-design, tubular, stainless steel, balloon-expandable stent (beStent) in the first 100 patients. One hundred forty-eight stents were used to treat 103 narrowings in the left anterior descending (n = 46), left circumflex (n = 20), and right coronary (n = 37) arteries. There were 85 de novo and 18 restenotic lesions (lesion length: <10 mm [31], 10 to 20 mm [43] >20 mm [29]; lesion type: A [10] B1 [29], B2 [20], C [44]; total occlusions, 23. More than 1 stent was used in 31 patients for treatment of long lesions that could not be covered by 1 stent. The stents used were 15-mm (n = 106), 25-mm (n = 38), or 35-mm (n = 4) long. Stent implantation strategy involved predilatation, deployment, and high-pressure dilatation, using the same balloon if possible. Clinical in-hospital success was 97% (2 patients had stent thrombosis that was recanalyzed, with myocardial infarction developing in 1, and 1 patient died on day 14 from retroperitoneal bleeding treated with surgery and complicated by sepsis). One-month event-free survival was 96%, with 1 death on day 21 due to hypertensive crisis. There were no other major adverse cardiac events in this first complex cohort of patients. In conclusion, the initial experience with this stent demonstrates its safety and efficiency for treating simple and complex coronary disease, with a relatively low rate of complications. Long-term clinical follow-up awaits further investigation.
Effects of Coronary Stenting on Restenosis and Occlusion After Angioplasty of the Culprit Vessel in Patients With Recent Myocardial Infarction

Christophe Bauters, Jean-Marc Lablanche, Eric Van Belle, Rodica Niculescu, Thibaud Meurice, Eugene P. McFadden, and Michel E. Bertrand

Background PTCA of an infarct-related lesion is associated with a high rate of restenosis and/or vessel occlusion. Recent studies have shown that coronary stenting in patients with stable or unstable angina is associated with a significant reduction in the restenosis rate compared with conventional balloon angioplasty. However, no information is available concerning the long-term effect of coronary stenting at infarct-related lesions compared with balloon angioplasty alone.

Methods and Results One hundred consecutive patients undergoing stent implantation at an infarct-related lesion and systematic 6-month angiographic follow-up were matched for major pre-PTCA clinical and angiographic variables with a group of patients undergoing conventional angioplasty. Preprocedural, postprocedural, and 6-month follow-up angiograms were analyzed with quantitative angiography. Coronary stenting was performed as a bailout procedure after failed balloon angioplasty in 20%, for a suboptimal result after balloon angioplasty in 71%, and electively in 9%. Stent implantation was associated with a higher acute gain than balloon angioplasty. At follow-up, the minimal lumen diameter was significantly (P<.0001) larger in the stent group (1.72±0.69 versus 1.23±0.72 mm). Restenosis (>50% DS at follow-up) occurred in 27% of the stent group versus 52% of the balloon group (P<.005). At follow-up, total occlusion at the dilated site occurred in 1% of the stent group versus 14% of the balloon group (P<.005).

Conclusions Coronary stenting of infarct-related lesions is associated with a highly beneficial effect on 6-month angiographic outcome compared with balloon angioplasty alone. Further studies are needed to establish whether the beneficial effect of coronary stenting on long-term vessel patency is associated with an improvement in left ventricular function or in clinical outcome.

Percutaneous Transluminal Septal Myocardial Ablation in Hypertrophic Obstructive Cardiomyopathy: Acute
Results and 3-Month Follow-Up in 25 Patients

Hubert Seggewiss, MD, Ulrich Gleichmann, MD, Lothar Faber, MD, Dieter Fassbender, MD, Henning K. Schmidt, MD, Stefan Strick, MD

Objectives. We report the acute results and midterm clinical course after percutaneous transluminal septal myocardial ablation (PTSMA) in symptomatic patients with hypertrophic obstructive cardiomyopathy (HOCM).

Background. In the treatment of HOCM, surgical myectomy and DDD pacemaker therapy are considered the standard procedural extensions to drug therapy with negatively inotropic drugs. As an alternative nonsurgical procedure for reducing the left ventricular outflow tract (LVOT) gradient, PTSMA by alcohol-induced septal branch occlusion was introduced. However, clinical follow-up has not been sufficiently described.

Methods. In 25 patients (13 women, 12 men; mean [±SD] age 54.7 ± 15.0 years) who were symptomatic despite sufficient drug therapy, 1.4 ± 0.6 septal branches were occluded with an injection of 4.1 ± 2.6 ml of alcohol (96%) to ablate the hypertrophied interventricular septum. After 3-months, follow-up results of LVOT gradients and clinical course were determined.

Results. The invasively determined LVOT gradients could be reduced in 22 patients (88%), with a mean reduction from 61.8 ± 29.8 mm Hg (range 4 to 152) to 19.4 ± 20.8 mm Hg (range 0 to 74) at rest (p < 0.0001) and from 141.4 ± 45.3 mm Hg (range 76 to 240) to 61.1 ± 40.1 mm Hg (range 0 to 135) after extrasystole. All patients had angina pectoris for 24 h. The maximal creatine kinase increase was 780 ± 436 U/liter (range 305 to 1,810) after 11.1 ± 6.0 h (range 4 to 24). Thirteen patients (52%) developed a trifascicular block for 5 min to 8 days requiring temporary (n = 8 [32%]) or permanent (DDD) pacemaker implantation (n = 5 [20%]). An 86-year old woman died 8 days after successful intervention of uncontrollable ventricular fibrillation in conjunction with beta-sympathomimetics in chronically obstructive pulmonary disease. The remaining patients were discharged after 11.3 ± 5.4 days (range 5 to 24), after an uncomplicated hospital course. Clinical and echocardiographic follow-up was achieved in all 24 surviving patients after 3 months. No cardiac complications occurred. Twenty-one patients (88%) showed clinical improvement, with a New York Heart Association functional class of 1.4 ± 1.1. A further reduction in LVOT gradient was shown in 14 patients (58%).

Conclusions. PTSMA of HOCM is a promising nonsurgical technique for septal myocardial reduction, with a consecutive reduction in LVOT gradient. Possible complications are trifascicular blocks, requiring permanent pacemaker implantation, and tachycardiac rhythm disturbances. Clinical long-term observations of larger patient series and a comparison with conventional forms of therapy are necessary to determine the conclusive therapeutic significance.
D Allele of the Angiotensin I-Converting Enzyme Is a Major Risk Factor for Restenosis After Coronary Stenting

Carole Amant, BS; Christophe Bauters, MD; Jean-Christophe Bodart, MD; Jean-Marc Lablanche, MD; Gilles Grollier, MD; Nicolas Danchin, MD; Martial Hamon, MD; Florence Richard, MD; Nicole Helbecque, PhD; Eugene P. McFadden, MRCPI; Philippe Amouyel, MD, PhD; Michel E. Bertrand, MD

Background. Although intracoronary stent implantation significantly reduces restenosis compared with balloon angioplasty, a minority of patients still develop restenosis predominantly due to neointimal hyperplasia. Experimental studies suggest that the renin-angiotensin system is involved in neointimal hyperplasia after arterial injury. In humans, the plasma and cellular levels of ACE are associated with an I/D genetic polymorphism in the ACE gene, DD patients having higher levels.

Methods and Results. We investigated a possible relation between the ACE I/D polymorphism and restenosis in 146 patients who underwent successful implantation of a Palmaz-Schatz stent and had 6-month follow-up angiography. The minimal lumen diameter (MLD) before and after the procedure did not differ significantly among the three groups of genotypes (DD, ID, and II). At follow-up, MLD had a significant inverse relationship to the number of D alleles present (DD, 1.65±0.71 mm; ID, 1.84±0.60 mm; II, 2.05±0.61 mm; P<.007). Late luminal loss during the follow-up period was significantly related to the number of D alleles (DD, 0.89±0.61 mm; ID, 0.60±0.52 mm; II, 0.40±0.53 mm; P<.0001). The relative risk of restenosis (defined as a >50% diameter stenosis at follow-up) approximated by the adjusted odds ratio was 2.00 per number of D alleles (95% confidence interval, 1.03 to 3.88, P<.04).

Conclusions. The ACE I/D polymorphism influences the level of late luminal loss after coronary stent implantation. These results suggest that the renin-angiotensin system may be implicated in the pathogenesis of restenosis after coronary stenting.

Summary
Adnan Kastrati, MD, Albert Schomig, MD, Shpend Elezi, MD, Helmut Schuhlen, MD, Josef Dirschinger, MD, Martin Hadamitzky, MD, Franz-Josef Neumann, MD.

Objectives. The objective of this study was to identify clinical, lesional and procedural factors that can predict restenosis after coronary stent placement.

Background. Coronary stent placement reduces the restenosis rate compared with that after percutaneous transluminal coronary angioplasty (PTCA). However, restenosis remains an unresolved issue, and identification of its predictive factors may allow further insight into the underlying process.

Methods. All patients with successful coronary stent placement were eligible for this study unless they had had a major adverse cardiac event during the 1st 30 days after the procedure. Of the 1,349 eligible patients (1,753 lesions), follow-up angiography at 6-months was performed in 80.4% (1,084 patients, 1,399 lesions). Demographic, clinical, lesional and procedural data were prospectively recorded and analyzed for any predictive power for the occurrence of late restenosis after stenting. Restenosis was evaluated by using three outcomes at follow-up: binary restenosis as a diameter stenosis ≥50%, late lumen loss as lumen diameter reduction and target lesion revascularization (TLR) as any repeat PTCA or coronary artery bypass surgery involving the stented lesion.

Results. Multivariate analysis demonstrated that diabetes mellitus, placement of multiple stents and minimal lumen diameter (MLD) immediately after stenting were the strongest predictors of restenosis. Diabetes increased the risk of binary restenosis with an odds ratio (OR) [95% confidence interval] of 1.86 [1.56 to 1.26] and the risk of binary restenosis with an OR of 1.81 [1.55 to 2.06] and that of TLR with an OR of 1.94 [1.66 to 2.22]. An MLD<3 mm at the end of the procedure augmented the risk of binary restenosis with an OR of 2.05 [1.77 to 2.34]. Classification and regression tree analysis demonstrated that the incidence of restenosis may be as low as 16% for a lesion without any of these risk factors and as high as 59% for a lesion with a combination of these risk factors.

Conclusions. Diabets, multiple stents and smaller final MLD are strong predictors of restenosis after coronary stent placement. Achieving an optimal result with a minimal number of stents during the procedure may significantly reduce this risk even in patients with adverse clinical characteristics such as diabetes.

Summary

1. Predictors of restenosis: diabetes mellitus, placement of multiple stents and MLD immediately after stenting were the strongest predictors of restenosis.

2. Diabetes increased the risk of binary restenosis with an odds ratio (OR) [95% confidence interval] of 1.86 [1.56 to 1.26] and the risk of binary restenosis with an OR of 1.81 [1.55 to 2.06] and that of TLR with an OR of
1.94 [1.66 to 2.22].

3. An MLD<3 mm at the end of the procedure augmented the risk of binary restenosis with an OR of 2.05 [1.77 to 2.34].

Restenosis: 16% for a lesion without any of these risk factors, 59% for a lesion with a combination of these risk factors.

Journal of the American College of Cardiology, 32:3:577-583

Coronary artery stenting in the elderly: short-term outcome and long-term angiographic and clinical follow-up

Joseph De Gregorio, Yoshio Kobayashi, Remo Albiero, Bernhard Reimers, Carlo Di Mario, Leo Finci, Antonio Colombo

Objectives. This study sought to compare the short- and long-term outcomes of elderly patients undergoing coronary artery stenting with those of younger patients and to determine the long-term clinical outcome and survival of elderly patients post stent implantation.

Background. Elderly patients undergoing coronary revascularization are considered a high-risk group. Few data exist that relate the results of stenting in treating coronary artery disease in the elderly population.

Methods. All elderly patients ≥75 years of age who underwent coronary artery stenting between March 1993 and July 1997 (n = 137) at our center were compared to the patients <75 who underwent coronary artery stenting during the same time period (n = 2,551). Long-term clinical follow-up and survival were determined for the elderly group.

Results. Elderly patients presented with lower ejection fractions (54% vs. 58%, p = 0.0001), more unstable angina (47% vs. 28%, p = 0.0001), and more multivessel disease (78% vs. 62%, p = 0.0001) than younger patients. These older patients had higher rates of procedure related complications including procedural myocardial infarction (MI) (2.9% vs. 1.7%, p = 0.2), emergency CABG (3.7% vs. 1.4%, p = 0.04), and death (2.2% vs. 0.12%, p = 0.0001). Angiographic follow-up, obtained in both groups, demonstrated significantly higher restenosis rates in the elderly versus younger patients (47% vs. 28%, p = 0.0007). Longer term clinical follow-up, which was obtained only in the elderly group, showed that at a mean follow-up period of 12 months post coronary stenting, elderly survival free from death, MI, revascularization and angina was 54% and that their overall survival was 91%. Subanalysis of the elderly patients who died showed much higher incidence of combined unstable angina (80%), prior MI (60%), lower ejection fraction (46%), multivessel disease (100%) and complex...
lesions (100%) than the overall group.

Conclusions. Elderly patients who undergo coronary artery stenting have significantly higher rates of procedural complications and worse six month outcomes than younger patients, especially those who present with combined unstable angina, history of MI, EF < 50%, multivessel disease and complex lesions. Overall survival in the elderly population at 12 months postcoronary artery stenting was 91% and event-free survival was 54%.

Journal of the American College of Cardiology, 32:3:584-589

The influence of diabetes mellitus on acute and late clinical outcomes following coronary stent implantation

Alexandre Abizaid, Ran Kornowski, Gary S. Mintz, Mun K. Hong, Andrea S. Abizaid, Roxana Mehran, Augusto D. Pichard, Kenneth M. Kent, Lowell F. Satler, Hongsheng Wu, Jeffrey J. Popma, Martin B. Leon

Objectives. We compared the clinical outcomes following coronary stent implantation in insulin-treated diabetes mellitus (IDDM), non-IDDM patients, and nondiabetic patients.

Background. Diabetic patients have increased restenosis and late morbidity following balloon angioplasty. The impact of diabetes mellitus (DM), especially IDDM, on in-stent restenosis is not known.

Methods. We studied 954 consecutive patients with native coronary artery lesions treated with elective Palmaz-Schatz stents implantation using conventional coronary angiographic and intravascular ultrasound methodology. Procedural success, major in-hospital complications, and 1-year clinical outcome were compared according to the diabetic status.

Results. In-hospital mortality was 2% in IDDM, significantly higher (p <0.02) compared with non-IDDM (0%) and nondiabetics (0.3%). Stent thrombosis did not differ among groups (0.9% in IDDM vs. 0% in non-IDDM and 0% in nondiabetics, p >0.1). During follow-up, target lesion revascularization (TLR) was 28% in IDDM, significantly higher (p <0.05) compared with non-IDDM (17.6%) and nondiabetics (16.3%). Late cardiac event-free survival (including death, myocardial infarction [MI], and any coronary revascularization procedure) was significantly lower (p = 0.0004) in IDDM (60%) compared with non-IDDM (70%) and nondiabetic patients (76%). By multivariate analysis, IDDM was an independent predictor for any late cardiac event (OR = 2.05, p = 0.0002) in general and TLR (odds ratio = 2.51, p = 0.0001) in particular.

Conclusions. In a large consecutive series of patients treated by elective stent implantation, IDDM patients were at higher risk for in-hospital mortality and subsequent TLR and, as a result, had a significantly lower
cardiac event-free survival rate. On the other hand, acute and long-term procedural outcome was found to be similar for non-IDDM compared with nondiabetic patients.

Journal of the American College of Cardiology, 32:7:1866-1873

Diabetes mellitus and the clinical and angiographic outcome after coronary stent placement

Shpend Elezi, Adnan Kastrati, Jurgen Pache, Anne Wehinger, Martin Hadamitzky, Josef Dirschinger, Franz-Josef Neumann, Albert Schomig

Objectives. The objectives of this study were to analyze the clinical and angiographic outcome of diabetic patients with successful coronary stent placement and to compare these results with those achieved after stenting in nondiabetic patients.

Background. The outcome of diabetic patients treated with stent placement due to coronary artery disease has not been assessed comprehensively.

Methods. This study analyzes a consecutive series of patients with successful stent placement comprising 715 patients with diabetes and 2,839 patients without diabetes. Clinical one year follow-up and angiographic control at 6 months were part of the protocol. Death, myocardial infarction and target lesion revascularization were considered as adverse events. An automated edge detection system was used for the angiographic assessment. The primary clinical endpoint was event-free survival at one year. The primary angiographic endpoint was restenosis rate at 6 months (≥50% diameter stenosis).

Results. Event-free survival was significantly lower in diabetic than in nondiabetic patients (73.1 vs. 78.5%, p < 0.001). Survival free of myocardial infarction was also significantly reduced in the diabetic group (89.9 vs. 94.4% in nondiabetics, p < 0.001). The incidence of both restenosis (37.5 vs. 28.3%, p < 0.001) and stent vessel occlusion (5.3 vs. 3.4%, p = 0.037) was significantly higher in diabetic patients. Diabetes was identified as an independent risk factor for adverse clinical events and restenosis in multivariate analyses.

Conclusions. Patients with diabetes mellitus have a less favorable clinical outcome at one year after successful stent placement as compared to the nondiabetic patients. The clinical follow-up was characterized by a higher incidence of death, myocardial infarction and reinterventions. Diabetic patients also demonstrated an increased risk for restenosis.
Coronary Wallstents show significant late, postprocedural expansion despite implantation with adjunct high-pressure balloon inflations

Clemens von Birgelen, Segei G. Airiian, Pim J. de Feyter, David P. Foley, Wim J. van der Giessen, Patrick W. Serruys

Adjunct high-pressure balloon inflations following the delivery of oversized self-expandable Wallstents may affect their implied late, postprocedural self-expansion. Consequently, we examined 15 agicWallstents, which were implanted following a strategy of stent oversizing and subsequent adjunct high-pressure balloon inflations (16 ±2 atm; all 12 atm). The excellent radiographic visibility of this stent permitted reliable quantitative coronary angiographic measurement of both lumen and stent dimensions (before and after stenting, and at follow-up). At follow-up, extent and distribution of in-stent neointimal proliferation were evaluated with volumetric intravascular ultrasound. Between postintervention and follow-up examination, mean stent diameter increased from 3.7 ± 0.4 to 4.2 ± 0.4 mm (p <0.0001); there was no significant difference in late stent expansion between proximal, mid-, and distal stent subsegments. Late stent expansion showed a significant (reverse) relation to maximum balloon size (r = -0.56, p <0.04), but not with follow-up lumen size or late lumen loss. On average, 52 ± 18% of the stent was filled with neointimal ingrowth; neointimal volume/cm stent length was 64 ± 22 mm3. Both late stent expansion (r = 0.36, p <0.02) and maximum balloon pressure (r = 0.41, p <0.001) were related to neointimal volume/cm stent but not to follow-up lumen size. Thus, despite high-pressure implantation, Wallstents showed significant late self-expansion, which resulted in larger stent dimensions at follow-up that assisted in accommodating in-stent neointimal proliferation. Conversely, late stent expansion had a significant relation to the extent of in-stent neointimal ingrowth. Beneficial and disadvantageous effects of the late stent expansion appear to be balanced, because a relation to late lumen loss or follow-up lumen dimensions was not found to be present.

Immediate and long-term outcomes of rotational atherectomy versus balloon angioplasty alone for treatment of diffuse in-stent restenosis
This study was performed to compare the effects of rotational atherectomy (RA) plus balloon angioplasty (BA) with those of BA alone for treatment of diffuse in-stent restenosis. RA+BA or BA alone was performed in a consecutive, prospective (not randomized) manner in 81 patients with 81 diffuse in-stent restenotic lesions (lesion length >10 mm): 36 patients underwent RA+BA, and 45 patients BA. Clinical recurrence was the primary end point of this study, and was defined as angina associated with objective evidence of myocardial ischemia on stress testing. Mean follow-up duration was 277 ± 109 days. In the BA group, acute lumen gain after repeat intervention was significantly lower than that of the original stenting procedure (1.94 ± 0.63 vs 2.37 ± 0.51 mm, p <0.05). In the RA + BA group, however, acute lumen gain of repeat intervention was similar to that of the original stenting procedure (2.16 ± 0.52 vs 2.26 ± 0.66 mm). Clinical recurrence rate at 6 months follow-up was significantly lower in the RA+BA group than in the BA group (25% vs 47%, p <0.05). Clinical events (death, myocardial infarction, repeat intervention) occurred in 6.7% (3 of 45) of patients in the BA group, but in no patient in the RA+BA group during the follow-up period. The long-term angina-free survival rate was significantly higher in the RA+BA group than in the BA group (72% vs 49%, p = 0.02). In conclusion, RA+BA seems to be a more effective therapeutic modality than BA alone for treatment of diffuse in-stent restenosis.


Six-Month Angiographic Outcome After Successful Repeat Percutaneous Intervention for In-Stent Restenosis

Christophe Bauters, Jean-Luc Banos, Eric Van Belle, Eugene P. McFadden, Jean-Marc Lablanche, and Michel E. Bertrand

Background-In-stent restenosis is an increasing clinical problem. Discordant results have been published regarding the risk of recurrent restenosis after repeat angioplasty for the treatment of in-stent restenosis.

Methods and Results-One hundred three consecutive patients (107 vessels) underwent repeat percutaneous intervention for the treatment of in-stent restenosis and were entered in a prospective angiographic follow-up program. Repeat balloon angioplasty was performed at 93 lesions (87%) and additional stenting at 14 lesions (13%). The primary success rate was 98%. Six-month angiographic follow-up was performed in 85% of eligible patients. Restenosis was determined by quantitative angiography. Restenosis defined as a >50% diameter stenosis at follow-up was observed at 22% of lesions. The rate of target-lesion revascularization at 6 months...
was 17%. Repeat intervention for diffuse in-stent restenosis and severe stenosis before repeat intervention were associated with significantly higher rates of recurrent restenosis. 

Conclusions-The overall restenosis rate after repeat intervention for in-stent restenosis is low. The subgroup of patients with diffuse and/or severe in-stent restenosis, however, is at higher risk of recurrent restenosis and may benefit from alternative therapeutic strategies.

Journal of the American College of Cardiology, 31:2:307-311

Efficacy of Coronary Stenting Versus Balloon Angioplasty in Small Coronary Arteries

Michael P. Savage, MD, FACC, David L. Fischman, MD, FACC, Randal Rake, BS, Martin B. Leon, MD, FACC, Richard A. Schatz, MD, FACC, Ian Penn, MD, FACC, Masakiyo Nobuyoshi, MD, FACC, Jeffrey Moses, MD, FACC, John Hirshfeld, MD, FACC, Richard Heuser, MD, FACC, Donald Baim, MD, FACC, Michael Cleman, MD, FACC, Jeffrey Brinker, MD, FACC, Sharon Gebhardt, RN, Sheldon Goldberg, MD, FACC for the Stent Restenosis Study (STRESS) Investigators

Objectives. The goal of this study was to compare the efficacy of elective stent implantation and balloon angioplasty for new lesions in small coronary arteries.

Background. Palmaz-Schatz stents have been designed and approved by the Food and Drug Administration for use in coronary arteries with diameters $\geq 3.0$ mm. The efficacy of elective stent placement in smaller vessels has not been determined.

Methods. By quantitative coronary angiography, 331 patients in the Stent Restenosis Study (STRESS) I-II were determined to have a reference vessel <3.0 mm in diameter. Of these, 163 patients were randomly assigned to stenting (mean diameter 2.69 $\pm$ 0.21 mm), and 168 patients were assigned to angioplasty (mean diameter 2.64 $\pm$ 0.24 mm). The primary end point was restenosis, defined as $\geq 50\%$ diameter stenosis at 6-month follow-up angiography. Clinical event rates at 1 year were assessed.

Results. Baseline clinical and angiographic characteristics were similar in the two groups. Procedural success was achieved in 100% of patients assigned to stenting and in 92% of patients assigned to angioplasty ($p < 0.001$). Abrupt closure within 30 days occurred in 3.6% of patients in both groups. Compared with angioplasty, stenting conferred a significantly larger postprocedural lumen diameter (2.26 vs. 1.80 mm, $p < 0.001$) and a larger lumen at 6 months (1.54 vs. 1.27 mm, $p < 0.001$). Restenosis ($\geq 50\%$ diameter stenosis at follow-up) occurred in 34% of patients assigned to stenting and in 55% of patients assigned to angioplasty ($p < 0.001$). At 1
year, event-free survival was achieved in 78% of the stent group and in 67% of the angioplasty group (p = 0.019).

Conclusions. These findings suggest that elective stent placement provides superior angiographic and clinical outcomes than balloon angioplasty in vessels slightly smaller than 3 mm.

Journal of the American College of Cardiology, 32:3:572-576

Stenting in acute coronary syndromes: a comparison of radial versus femoral access sites

Tift Mann, Gabriela Cubeddu, Josie Bowen, Joel E. Schneider, Michael Arrowood, William N. Newman, Michael J. Zellinger, Gregory C. Rose

Objectives. The purpose of the present study was to compare the radial approach with the femoral approach for coronary stenting in patients with acute coronary syndromes.

Background. Aggressive anticoagulation in patients with acute coronary syndromes increases the risk of femoral vascular complications. The transradial approach has the potential to significantly reduce the incidence of access site bleeding complications in this group of patients.

Methods. One hundred forty-two patients with acute coronary syndromes undergoing coronary stenting were prospectively randomized to have their procedure performed from either the radial or femoral access site and the results compared.

Results. Nine of 74 patients randomized to the radial group crossed over to the femoral group (6 negative Allen tests, 3 access failures). Patient demographics were the same in both groups. Primary success was identical: 96% radial, 96% femoral, ns. There were no procedural myocardial infarctions or deaths, and no patient was referred for emergency bypass surgery. There were no access site bleeding complications in the radial group as opposed to 3 (4%) in the femoral group, p < 0.01. Postprocedure length of stay, days (1.4 ± 0.2 radial vs. 2.3 ± 0.4 femoral, p < 0.01) as well as total hospital length of stay (3.0 ± 0.3 radial vs. 4.5 ± 0.5 femoral, p < 0.01) were significantly reduced in the radial group. Total hospital charge was also significantly lower in the radial group ($20,476 ± 811 radial versus $23,389 ± 1,180 femoral, p < 0.01).

Conclusion. Coronary stenting from the radial approach is efficacious in patients with acute coronary syndromes. Access site bleeding complications are less, and early ambulation results in a shorter hospital length of stay. There was a 15% reduction in total hospital charge in the radial group.
Predictors of Restenosis After Coronary Stent Implantation

Christophe Bauters, MD, FACC, Edouard Hubert, MD, Alain Prat, MD, Karim Bougrimi, MD, Eric Van Belle, MD, Eugene P. McFadden, MRCPI, FACC, Philippe Amouyel, MD, Jean-Marc Lablanche, MD, FACC, Michel Bertrand, MD, FACC

Objectives. We sought to determine predictors of restenosis after coronary stenting (CS) in a consecutive series of patients.

Background. Although stenting in highly selected patient groups reduces restenosis, the results of stenting in a heterogeneous patient group and the effects of clinical and procedural factors on stent restenosis are currently unclear.

Methods. We analyzed the 6-month angiographic outcome of 500 lesions in 463 consecutive patients undergoing successful CS. Clinical, qualitative and quantitative angiographic variables were correlated with restenosis assessed as both a binary and a continuous variable.

Results. Restenosis, defined as the presence of >50% diameter stenosis in the dilated segment, was present in 105 (26%) of the 405 lesions with angiographic follow-up. The mean late lumen loss during the follow-up period was 0.79 ± 0.64 mm. Implantation of multiple stents (p < 0.0001) and a high acute gain (p < 0.0002) were independently associated with a higher late lumen loss. In contrast, the use of high inflation pressure (p < 0.02) and Palmaz-Schatz stents (p < 0.005) was independently associated with a lower late lumen loss. When restenosis was defined as a qualitative variable, implantation of multiple stents (p < 0.001), stenosis length (p < 0.01), small reference diameter (p < 0.02) and stent type other than Palmaz-Schatz (p < 0.01) were independent predictors of restenosis. None of the clinical variables tested was associated with restenosis.

Conclusions. Coronary stenting in an unselected patient group is associated with an acceptable restenosis rate. Although some risk factors were identified, the risk of restenosis was not related to most of the variables tested. This suggests that the superiority of CS over balloon angioplasty, in terms of restenosis, might also apply to subgroups of patients that were not included in the recent randomized studies.


Comparison of the sheath delivery system versus bare stenting for coronary stent implantation
Outside the United States, Palmaz-Schatz coronary stents are implanted by hand-crimping the stent to a high pressure balloon without the use of a protective sheath. This lowers the delivery profile, increases the ease of deployment, and ensures that the postdilatation balloon is centered on the stent. To assess this bare stenting technique, 209 patients were retrospectively analyzed: 92 patients (107 lesions) with the sheath protected stent delivery system (SDS) and 117 patients (150 lesions) with the bare stent approach. The number of balloons used per lesion in the bare stent group was significantly less than in the SDS group (1.9 ± 0.6 vs. 3.8 ± 1.2, P < 0.0001). In addition, the procedure time in the bare stent group was significantly shorter than in the SDS group (106 ± 55 vs. 134 ± 60 min, P = 0.001). There was no difference in frequency of adverse events or stent displacement during the procedure. The bare stenting technique decreases the procedure time, reduces the number of balloons used, and is as safe as the SDS approach.


Coronary stenting in the elderly: Longitudinal results in a wide spectrum of patients treated with a new and more practical approach


One hundred-twelve intracoronary stents (83 Palmaz-Schatz, 25 biliary, and 4 Gianturco-Roubin) were placed in 87 (51.7% male) patients aged 70 years (70-93; mean 76.1) during a 1-year period. All stents were deployed using high-pressure inflation (mean 17.4 ± 2 atm) without intravascular ultrasound. All patients received antiplatelet therapy with aspirin and ticlopidine. Seven patients additionally received warfarin at the physician’s discretion. No patient was excluded from analysis regardless of presentation (40% acute myocardial infarction and 12.6% bailout) or complication. There were four deaths and two target vessel reinterventions in-hospital. One reintervention (a bailout) developed a non-Q-wave myocardial infarction. Bleeding, vascular complications, and length of stay were all greater for the warfarin group. The event-free
survival rate was 83.9%, at an average of 8.6 months follow-up. A wide range of elderly patients can thus undergo stenting without intravascular ultrasound, usually without warfarin, yielding results comparable to those with more standard therapy in select populations.


Nonischemic Chest Pain Induced by Coronary Interventions : A Prospective Study Comparing Coronary Angioplasty and Stent Implantation

Allen Jeremias, Sven Kutscher, Michael Haude, Dagmar Heinen, Gerald Holtmann, Wolfgang Senf, and Raimund Erbel

Background-Chest pain frequently occurs without any signs of ischemia within the first 24 hours after coronary interventions. To test the hypothesis that this pain may be due to local vessel injury (“stretch pain”), we performed a prospective study enrolling patients after PTCA, stent implantation, or diagnostic coronary angiography alone.

Methods and Results-A total of 145 patients after coronary angiography were evaluated by a validated questionnaire for quantifying postinterventional chest pain within 24 hours. To detect myocardial ischemia, all patients were evaluated with a 12-lead ECG and cardiac isoenzymes immediately after the procedure and the morning after. After stent implantation, 21 of the 51 patients (41.2%) developed chest pain, compared with 4 of the 33 patients (12.1%) undergoing PTCA and 6 of the 61 patients (9.8%) with a diagnostic angiography (P<0.001). Of these 31 patients who developed chest pain, only 3 (9.7%) felt that the pain was similar to previously experienced angina pectoris. The minimal lumen diameter after intervention was significantly larger in the stent group than in the PTCA group (3.14±0.75 versus 1.95±0.67 mm; P<0.001). No patient had changes in the ECG compared with before intervention, but 3 patients after stent implantation had a rise in cardiac isoenzymes. No other major adverse cardiac events occurred until discharge.

Conclusions-Nonischemic chest pain develops in almost half of all patients undergoing stent implantation and seems to be related to vessel overexpansion caused by the stent in the diseased vessel segment.

The American Journal of Cardiology, 81:7:860-865
One-Year Follow-Up of The Stent Restenosis (STRESS I) Study

Charles J. George, MS, Donald S. Baim, MD, Jeffrey A. Brinker, MD, David L. Fischman, MD, Sheldon Goldberg, MD, Richard Holubkov, PhD, Elizabeth D. Kennard, PhD, Lisa Veltri, MS, Katherine M. Detre, MD, DrPH

We present the completed 1-year follow-up results of the original Stent Restenosis Study (STRESS I), in which 407 patients with symptomatic ischemic heart disease and new lesions of the native coronary circulation were randomly assigned to treatment with either the Palmaz-Schatz coronary stent or conventional percutaneous transluminal coronary angioplasty (PTCA). The present study compares the safety of elective stenting to balloon angioplasty (PTCA) in terms of freedom from clinical events up to 1 year after treatment. Patients were enrolled and treated from January 1991 through February 1993, and follow-up data were collected and verified until July 1995. Ninety-seven percent of all patients had complete follow-up (deceased or alive with known clinical status) beyond 8 months, and 94% beyond 11 months. Anginal status between 9 to 15 months postprocedure was available for 78% of patients. At 1 year, 154 patients (75%) assigned to stent implantation and 141 (70%) to PTCA were free of all clinical events (death, myocardial infarction, or any revascularization procedure), and 162 stent patients (79%) and 149 PTCA patients (74%) were free from death, myocardial infarction, or target lesion revascularization. Symptom-driven target lesion revascularization occurred in 12% of the stent group versus 17% of the PTCA group. None of these differences in clinical events was statistically significant. Only 2 patients in the stent group and 7 in the PTCA group had a first event after 239 days, and freedom from angina at 1 year was reported in equal frequency in both groups (84%). There appear to be no late adverse effects of stent implantation. However, these results are limited by low statistical power, narrow patient selection, and the anticoagulation regimen used in the early experience with this device.

Journal of the American College of Cardiology, 32:5:1351-1357

Optimal coronary balloon angioplasty with provisional stenting versus primary stent (OCBAS) : Immediate and long-term follow-up results

Alfredo Rodriguez, Francisco Ayala, Victor Bernardi, Omar Santaera, Eugenio Marchand, Cesar Pardinas, Carlos Mauvecin, Daniel Vogel, Lari C. Harrell, Igor F. Palacios on behalf of the OCBAS investigators
Objective. This study sought to compare two strategies of revascularization in patients obtaining a good immediate angiographic result after percutaneous transluminal coronary angioplasty (PTCA): elective stenting versus optimal PTCA. A good immediate angiographic result with provisional stenting was considered to occur only if early loss in minimal luminal diameter (MLD) was documented at 30 min post-PTCA angiography.

Background. Coronary stenting reduces restenosis in lesions exhibiting early deterioration (>0.3 mm) in MLD within the first 24 hours (early loss) after successful PTCA. Lesions with no early loss after PTCA have a low restenosis rate.

Methods. To compare angiographic restenosis and target vessel revascularization (TVR) of lesions treated with coronary stenting versus those treated with optimal PTCA, 116 patients were randomized to stent (n = 57) or to optimal PTCA (n = 59). After randomization in the PTCA group, 13.5% of the patients crossed over to stent due to early loss (provisional stenting).

Results. Baseline demographic and angiographic characteristics were similar in both groups of patients. At 7.6 months, 96.6% of the entire population had a follow-up angiographic study: 98.2% in the stent and 94.9% in the PTCA group. Immediate and follow-up angiographic data showed that acute gain was significantly higher in the stent than in the PTCA group (1.95 vs. 1.5 mm; p < 0.03). However, late loss was significantly higher in the stent than the PTCA group (0.63 ± 0.59 vs. 0.26 ± 0.44, respectively; p = 0.01). Hence, net gain with both techniques was similar (1.32 ± 0.3 vs. 1.24 ± 0.29 mm for the stent and the PTCA groups, respectively; p = NS). Angiographic restenosis rate at follow-up (19.2% in stent vs. 16.4% in PTCA; p = NS) and TVR (17.5% in stent vs. 13.5% in PTCA; p = NS) were similar. Furthermore, event-free survival was 80.8% in the stent versus 83.1% in the PTCA group (p = NS). Overall costs (hospital and follow-up) were US $591,740 in the stent versus US $398,480 in the PTCA group (p < 0.02).

Conclusions. The strategy of PTCA with delay angiogram and provisional stent if early loss occurs had similar restenosis rate and TVR, but lower cost than primary stenting after PTCA.

Circulation 1998;97: 2396-2401

Interlesion Dependence of the Risk for Restenosis in Patients With Coronary Stent Placement in Multiple Lesions

Adnan Kastrati, Albert Schomig, Shpend Elezi, Helmut Schuhlen, Manfred Wilhelm, and Josef Dirschinger
Background—Little is known about the behavior with regard to restenosis of multiple lesions within the same patient treated with intracoronary stenting. Our objective was to test the hypothesis that there is an intrapatient dependence of restenosis between lesions.

Methods and Results—Quantitative analysis was carried out on angiograms obtained before, immediately after, and at 6 months after coronary stent placement in 1734 lesions in 1244 patients. We used a specialized logistic regression that not only accounts for intraclass correlation but also quantifies it in the form of odds ratio (OR) as the change in risk of a lesion to develop restenosis if another companion lesion had restenosis. The model was based on 23 patient- and lesion-related variables with binary restenosis (diameter stenosis 50%) as end point. The overall restenosis rate was 27.5%: 24.4% for single-lesion, 28.6% for double-lesion, and 33.8% for 3-lesion interventions. After adjustment for the influence of significant factors (hypercholesterolemia, systemic arterial hypertension, diabetes mellitus, previous PTCA, ostial lesion, location in left anterior descending coronary artery, number of stents placed, vessel size, stenosis severity, balloon-to-vessel ratio, and final result), the analysis found a significant intrapatient correlation, OR 2.5 (1.8 to 3.6). This means that in patients with multilesion interventions, the risk of a lesion to develop restenosis is 2.5 times higher if a companion lesion has restenosis, independently of the presence or absence of analyzed patient risk factors (eg, diabetes).

Conclusions—This study demonstrates that there is a dependence of restenosis between coronary lesions in patients who undergo a multilesion intervention. The likelihood of restenosis for a lesion is higher when another companion lesion has also developed restenosis. Other, as yet unidentified patient factors may be the source of this intrapatient correlation of restenosis.

The American Journal of Cardiology, 83:12:1617-1622

Influence of lesion length on restenosis after coronary stent placement

Adnan Kastrati, Shpend Elezi, Josef Dirschinger, Martin Hadamitzky, Franz-Josef Neumann, Albert Schomig

The length of a coronary lesion is a significant predictor of restenosis after balloon angioplasty. The influence of lesion length has not comprehensively been assessed after coronary stent placement. This study includes 2,736 consecutive patients with coronary stent placement. Only patients with recent or chronic occlusions before the intervention were excluded. Patients were divided in 2 groups: 573 patients with long lesions (≥15 mm) and 2,163 patients with short lesions (<15 mm). There were no significant differences between the groups with respect to the procedural success rate and incidence of subacute thrombosis. One-year event-free survival was
lower in patients with long lesions (73.3% vs 80.0%, \( p = 0.001 \)). Six-month angiography was performed in 82.5% of the eligible patients. The incidence of binary restenosis (≥50% diameter stenosis) was higher in patients with long lesions (36.9% vs 27.9%, \( p < 0.001 \)). Similarly, patients with long lesions presented more late lumen loss than those with short lesions (1.29 ± 0.89 vs 1.07 ± 0.77 mm, \( p < 0.001 \)). Multivariate models for both binary restenosis and late lumen loss demonstrated that lesion length was an independent risk factor for restenosis. The risk was further increased by multiple stent placement and overlapping stents that were also independent risk factors of restenosis. Stented segment length did not show any independent effect. Therefore, long lesions represent an independent risk factor for restenosis after coronary stent placement. The results of this study suggest that a possible way to reduce the risk is to cover the lesion with a minimal number of nonoverlapping stents.

Circulation 1998;98: 112-118

Mechanisms of Residual Lumen Stenosis After High-Pressure Stent Implantation : A Quantitative Coronary Angiography and Intravascular Ultrasound Study

Javier Bermejo, Javier Botas, Eulogio Garcia, Jaime Elizaga, Julio Osende, Javier Soriano, Manuel Abeytua, and Juan Luis Delcan

Background—Intravascular ultrasound (IVUS) studies have demonstrated that stents are frequently suboptimally expanded despite the use of high pressures for deployment. The purpose of this study was to identify the mechanisms responsible for such residual lumen stenosis.

Methods and Results—Fifty-seven lesions from 50 patients treated with high-pressure (median±interquartile range, 14±2 atm) elective (44 de novo, 13 restenotic lesions) stenting were prospectively studied (29 Wiktor, Medtronic; 28 Palmaz-Schatz, Cordis Corp). Balloon subexpansion was calculated as the difference between maximal and minimal balloon cross-sectional areas at peak pressure measured by automatic edge detection; elastic recoil was calculated as the difference between minimal measured balloon size and IVUS-derived minimal lumen area within the stent. Angiographic residual diameter stenosis was 10±13% (reference diameter, 3.1±0.7 mm; balloon to artery ratio, 1.12±0.23) and IVUS-derived stent expansion was 80±28%. However, although balloon nominal size was 9.6±1.3 mm² and maximal balloon size measured inside the coronary lumen was 12.5±3.2 mm², final stent minimal lumen area was only 7.1±2.2 mm². Balloon subexpansion of 4.0 ±1.8 mm² (33%) and elastic recoil of 1.6±2.3 mm² (20%) (both \( P < 0.0001 \)) were the two mechanisms responsible for residual luminal stenosis. Wiktor stent and peak inflation pressure correlated with balloon subexpansion, whereas Wiktor stent, de novo lesion, and minimal lumen area at baseline correlated with elastic recoil.

Conclusions—Despite high-pressure deployment, lumen dimensions after stenting are only 57% of maximal...
achievable. Inadequate balloon expansion and elastic recoil are responsible for residual lumen stenosis, suggesting that plaque characteristics and stent resistance deserve further investigation.

Circulation 1998;98: 104-111

Intracoronary Stenting and Risk for Major Adverse Cardiac Events During the First Month

Helmut Schuhlen, Adnan Kastrati, Josef Dirschinger, Jorg Hausleiter, Shpend Elezi, Anne Wehinger, Jurgen Pache, Martin Hadamitzky, and Albert Schomig

Background-Our rationale for this study was to analyze the risk for procedural failure of attempted stenting and the risk for major adverse cardiac events (MACE) after success and to develop a risk stratification protocol for successful procedures.

Methods and Results-Stenting was attempted in 2894 procedures during the 5-year study period (success in 98.3% of 3815 lesions). After failure, the MACE rate was 42.6%. The risk for failure was higher for lesions in the left circumflex coronary artery or in venous bypass grafts and after an acute occlusion before stenting; it increased with stenosis length or grade and decreased with vessel size and growing institutional experience in stenting. After success, death occurred in 0.8%, death or myocardial infarction in 2.0%, and any MACE in 3.6%. Independent risk factors for MACE were older age, diabetes, acute myocardial infarction, unstable angina, impaired left ventricular function, residual dissections, stent overlap, longer stented segments, and a postprocedural regimen without ticlopidine. Procedural factors were substantially stronger predictors than operator-independent variables available before procedures. Overall, the risk declined after the first 3 days. Two major factors exhibited time-dependent variations of their influence: while residual dissections were the dominant risk factor within the first 3 days with a reduction after that, no protective effect of ticlopidine could be identified before day 3. From these results, we derived a risk stratification protocol for individual procedures.

Conclusions-These results underscore the importance of optimal angiographic results and the need for antiplatelet regimens with immediate onset. Our risk stratification protocol may guide individual postprocedural care and allow us to compare risk profiles of different study populations and to devise quality control programs for stenting.
Balloon angioplasty for the treatment of coronary in-stent restenosis: immediate results and 6-month angiographic recurrent restenosis rate

Helene Eltchaninoff, Rene Koning, Christophe Tron, Vivek Gupta, Alain Cribier

Objectives. The purpose of this prospective study was to evaluate the immediate results and the 6-month angiographic recurrent restenosis rate after balloon angioplasty for in-stent restenosis.

Background. Despite excellent immediate and mid-term results, 20% to 30% of patients with coronary stent implantation will present an angiographic restenosis and may require additional treatment. The optimal treatment for in-stent restenosis is still unclear.

Methods. Quantitative coronary angiography (QCA) analyses were performed before and after stent implantation, before and after balloon angioplasty for in-stent restenosis and on a 6-month systematic coronary angiogram to assess the recurrent angiographic restenosis rate.

Results. Balloon angioplasty was performed in 52 patients presenting in-stent restenosis. In-stent restenosis was either diffuse (≥10 mm) inside the stent (71%) or focal (29%). Mean stent length was 16 ± 7 mm. Balloon diameter of 2.98 ± 0.37 mm and maximal inflation pressure of 10 ± 3 atm were used for balloon angioplasty. Angiographic success rate was 100% without any complication. Acute gain was lower after balloon angioplasty for in-stent restenosis than after stent implantation: 1.19 ± 0.60 mm vs. 1.75 ± 0.68 mm (p = 0.0002). At 6-month follow-up, 60% of patients were asymptomatic and no patient died. Eighteen patients (35%) had repeat target vessel revascularization. Angiographic restenosis rate was 54%. Recurrent restenosis rate was higher when in-stent restenosis was diffuse: 63% vs. 31% when focal, p = 0.046.

Conclusions. Although balloon angioplasty for in-stent restenosis can be safely and successfully performed, it leads to less immediate stenosis improvement than at time of stent implantation and carries a high recurrent angiographic restenosis rate at 6 months, in particular in diffuse in-stent restenosis lesions.
Richard C. Becker, Judith S. Hochman, Christopher P. Cannon, Frederick A. Spencer, Steven P. Ball, Michael J. Rizzo, Elliott M. Antman for the TIMI 9 Investigators

Objectives
The purpose of this study was to determine the incidence and demographic characteristics of patients experiencing cardiac rupture after thrombolytic and adjunctive anticoagulant therapy and to identify possible associations between the mechanism of thrombin inhibition (indirect, direct) and the intensity of systemic anticoagulation with its occurrence.

Background
Cardiac rupture is responsible for nearly 15% of all in-hospital deaths among patients with myocardial infarction (MI) given thrombolytic agents. Little is known about specific patient- and treatment-related risk factors.

Methods
Patients (n = 3,759) with MI participating in the Thrombolysis and Thrombin Inhibition in Myocardial Infarction 9A and B trials received intravenous thrombolytic therapy, aspirin and either heparin (5,000 U bolus, 1,000 to 1,300 U/h infusion) or hirudin (0.1 to 0.6 mg/kg bolus, 0.1 to 0.2 mg/kg/h infusion) for at least 96 h. A diagnosis of cardiac rupture was made clinically in patients with sudden electromechanical dissociation in the absence of preceding congestive heart failure, slowly progressive hemodynamic compromise or malignant ventricular arrhythmias.

Results
A total of 65 rupture events (1.7%) were reported—all were fatal, and a majority occurred within 48 h of treatment. Patients with cardiac rupture were older, of lower body weight and stature and more likely to be female than those without rupture (all p < 0.001). By multivariable analysis, age >70 years (odds ratio [OR] 3.77; 95% confidence interval [CI] 2.06, 6.91), female gender (OR 2.87; 95% CI 1.44, 5.73) and prior angina (OR 1.82; 95% CI 1.05, 3.16) were independently associated with cardiac rupture. Independent predictors of nonrupture death included age >70 years (OR 3.68; 95% CI 2.53, 5.35) and prior MI (OR 2.14; 95%, CI 1.45, 3.17). There was no association between the type of thrombin inhibition, the intensity of anticoagulation and cardiac rupture.

Conclusions
Cardiac rupture following thrombolytic therapy tends to occur in older patients and may explain the disproportionately high mortality rate among women in prior clinical trials. Unlike major hemorrhagic complications, there is no evidence that the intensity of anticoagulation associated with heparin or hirudin administration influences the occurrence of rupture.
Impact of Intravascular Ultrasound Guidance in Stent Deployment on 6-Month Restenosis Rate: A Multicenter, Randomized Study Comparing Two Strategies - With and Without Intravascular Ultrasound Guidance

Francois Schiele, MD, Nicolas Meneveau, MD, Alain Vuillemenot, MD, Da Dong Zhang, MD, Sanjiv Gupta, MD, Mariette Mercier, MD, Nicloas Danchin, MD, FACC, FESC, Bernard Bertrand, MD, Jean-Pierre Bassand, MD, FACC, FESC, on behalf of the RESIST Study Group

Objectives. We aimed to investigate the impact of intravascular ultrasound (IVUS)-guided stent implantation on the 6-month restenosis rate, which has not yet been fully established in randomized trials.

Background. The 6-month angiographic restenosis rate was compared in patients with symptomatic ischemic heart disease who were randomly allocated to angioplasty and stent deployment, with versus without IVUS guidance.

Methods. After successful stent implantation, patients were randomized into two groups: Group A had no further dilation, and Group B had additional balloon dilation until achievement of IVUS criterion for stent expansion. The study group consisted of 164 patients, assuming a 50% reduction of the restenosis rate in Group B (15% vs. 30%) (alpha = 10%, beta = 20%).

Results. We enrolled 155 patients. Overdilation was carried out in 31 (39%) of 79 Group B patients, with the IVUS criterion being achieved in 63 (80%) of 79. No significant difference was observed in the minimal luminal diameter (MLD), but the stent lumen cross-sectional area (CSA) was significantly larger in Group B (mean ± SD) (7.16±2.48 vs. 7.95 ± 2.21 mm2, p=0.04). At 6 months, there was no significant difference in the restenosis rate, (28.8% [21 of 73] in Group A vs. 22.5% [16 of 71] in Group B, p=0.25), but according to the observed difference in the restenosis rate, the power of the study was only 40%. The difference in MLD was also nonsignificant (1.60±0.65 mm in Group A vs. 1.70±0.64 mm in Group B, p=0.20), whereas the lumen CSA was 20% larger in the IVUS-guided group (4.47±2.59 vs. 5.36±2.81 mm2, p=0.03). Lumen CSA was the only predictor of restenosis by multivariate logistic regression analysis.

Conclusions. A nonsignificant 6.3% absolute reduction in the restenosis rate and a nonsignificant difference in MLD were observed in the study. Nonetheless, we still cannot rule out a beneficial effect of IVUS guidance, although this may have gone undetected owing to a lack of statistical power. A significant increase was observed in immediate and 6-month lumen size, as detected by IVUS, indicating that ultrasound guidance in stent deployment may be beneficial.
The objective of this study was to assess the short- and long-term outcome of patients undergoing coronary stenting for chronic total occlusions compared with a control patient population with nonocclusive stenoses. A total of 789 consecutive patients (1,043 lesions) underwent coronary stenting using a high-pressure stent optimization technique. The study population was divided into total occlusion group (94 consecutive patients [95 lesions] with chronic total occlusions) and subtotal occlusion group (695 consecutive patients [948 lesions] with nonocclusive stenoses). There was no difference in postprocedure angiographic minimum lumen diameter (3.13±0.48 vs 3.15±0.57 mm, p=0.72) and minimum intrastent cross-sectional area by intravascular ultrasound (7.31±2.06 vs 7.64±2.53 mm2, p=0.26) between the total and subtotal groups, respectively. Subacute thrombosis occurred in 2 patients (2.1%) in the total group compared with 9 patients (1.3%) in the subtotal group (p=0.63). Angiographic restenosis occurred in 27% vs 22% (p=0.40) and repeat angioplasty in 15% vs 13% (p=0.62) in the total and subtotal groups, respectively. Thus, coronary stenting of chronic total occlusions after successful recanalization could be performed with a high successful rate. In addition, the incidence of stent thrombosis, angiographic restenosis, and the need for target lesion revascularization is comparable to that of an unselected cohort of patients with nonocclusive stenoses.
Stent Implantation Versus Balloon Angioplasty in Chronic Coronary Occlusions: Results From the GISSOC Trial

Paolo Rubartelli, MD, Luigi Niccoli, MD, Edoardo Verna, MD, Corinna Giachero, MD, Marco Zimarino, MD, Alessandro Fontanelli, MD, Corrado Vassanelli, MD, Luigi Campolo, MD, Eugenio Martuscelli, MD, Giorgio Tommasini, MD, for the Gruppo Italiano Di Studio sullo Stent nelle Occlusioni Coronariche (GISSOC)
Genoa, Brescia, Varese, Gualdo Tadino, Udine, Verona, Milan, Rome and Treviglio, Italy

Objectives. In this multicenter, randomized trial evaluated whether stent implantation after successful recanalization of a chronic coronary occlusion reduced the incidence of restenosis.

Background. Percutaneous transluminal coronary angioplasty (PTCA) in chronic total occlusions is associated with a higher rate of angiographic restenosis and reocclusion than PTCA in subtotal stenoses. Preliminary reports have suggested a decreased restenosis rate after stent implantation in coronary total occlusions.

Methods. We randomly assigned 110 patients with recanalized total occlusion to Palmaz-Schatz stent implantation, followed by 1 month of anticoagulant therapy versus no other treatment. The primary end point was the minimal lumen diameter (MLD) of the treated segment at follow-up, as determined by quantitative angiography at a core laboratory.

Results. Repeat coronary angiography was performed 9 months after the procedure in 88% of patients. The MLD (mean ± SD) at follow-up was 1.74±0.88 mm in patients assigned to stent implantation and 0.85±0.75 mm in patients assigned to PTCA (p<0.001). Stent implantation was associated with a lower incidence of restenosis (defined as diameter stenosis ≥50% at follow-up) (32% vs. 68%, p<0.001) and reocclusion (8% vs. 34%, p=0.003) than balloon PTCA. Likewise, stent-related patients had less recurrent ischemia (14% vs. 46%, p=0.002) and target lesion revascularization (5.3% vs. 22%, p=0.038), but experienced a longer hospital stay.

Conclusions. Palmaz-Schatz stent implantation after successful balloon PTCA of chronic total occlusions improves the midterm angiographic and clinical outcome and could be the preferred treatment option in selected with occluded vessels.

Summary

The American Journal of Cardiology, 1998;82:2:144-147

Effects of probucol and cilostazol alone and in combination on frequency of poststenting restenosis
The present study was conducted to assess the preventive effect of combined treatment with probucol, an antioxidant, and cilostazol, a phosphodiesterase inhibitor, against poststenting restenosis. Study patients were randomized to 4 modality groups 1 week before stenting: control, probucol (500 mg/day), cilostazol (200 mg/day), and probucol plus cilostazol. Treatment on these modalities was conducted from 5 prestent days until the poststenting follow-up evaluation (6 poststenting months). All patients received aspirin (81 mg/day). The efficacy of each modality against restenosis was evaluated in a total 126 patients with 165 coronary arterial lesions, using a quantitative method. The decrease in luminal diameter at the poststenting follow-up was 1.04 ± 0.57 mm for controls, 0.88 ± 0.82 mm for those taking probucol, 0.61 ± 0.59 mm for those taking cilostazol (p <0.05 vs control), and 0.40 ± 0.52 mm (p <0.01 vs control) for the combined treatment group. Restenosis rate per segment was 31.7% for controls, 16.7% for the probucol group, 12.5% for the cilostazol group (p <0.05 vs control), and 9.5% for the combined treatment group (p <0.05 vs the control). Neither mortality, myocardial infarction, stent thrombosis, or coronary bypass surgery, nor any serious complications were observed in the combined treatment group. Combined treatment with probucol and cilostazol has thus proved safe and effective in preventing acute poststenting complications and suppressing chronic restenosis.

Lancet 1998; 352: 673-81

Randomised comparison of implantation of heparin-coated stents with balloon angioplasty in selected patients with coronary artery disease (Benestent II)

Patrick W Serruys, Ben van Hout, Hans Bonnier, Victor Legrand, Eulogio Garcia, Carlos Macaya, Eduardo Sousa, Wim van der Giessen, Antonio Colombo, Ricardo Seabra-Gomes, Ferdinand Kiemeneij, Peter Ruygrok, John Ormiston, Hakan Emanuelsson, Jean Fajadet, Michael Haude, Silvio Klugmann, Marie-Angele Morel, for the Benestent Study Group*.

Background. The multicentre, randomised Benestent-II study investigated a strategy of implantation of a heparin-coated Palmar-Schatz stent plus antiplatelet drugs compared with the use of balloon angioplasty in
selected patients with stable or stabilised unstable angina, with one or more de-novo lesions, less than 18 mm long, in vessels of diameter 3 mm or more.

Methods. 827 patients were randomly assigned stent implantation (414 patients) or standard balloon angioplasty (413 patients). The primary clinical endpoint was event-free survival at 6 months, including death, myocardial infarction, and the need for revascularisation. The secondary endpoints were the restenosis rate at 6 months and the cost-effectiveness at 12 months. There was also one-to-one subrandomisation to either clinical and angiographic follow-up or clinical follow-up alone. Analyses were by intention to treat.

Findings. Four patients (one stent group, three angioplasty group) were excluded from analysis since no lesion was found. At 6 months, a primary clinical endpoint had occurred in 53 (12.8%) of 413 patients in the stent group and 79 (19.3%) of 410 in the angioplasty group (p=0.013). This significant difference in clinical outcome was maintained at 12 months. In the subgroup assigned angiographic follow-up, the mean minimum lumen diameter was greater in the stent group than in the balloon-angioplasty group, (1.89 [SD 0.65] vs 1.66 [0.57] mm, p=0.0002), which corresponds to restenosis rates (diameter stenosis ≥50%) of 16% and 31% (p=0.0008). In the group assigned clinical follow-up alone, event-free survival rate at 12 months was higher in the stent group than the balloon-angioplasty group (0.89 vs 0.79, p=0.004) at a cost of an additional 2085 Dutch guilders (US$1020) per patient.

Interpretation. Over 12-month follow-up, a strategy of elective stenting with heparin-coated stents is more effective but also more costly than balloon angioplasty.

Circulation 1998;98: 200-203

Early Lumen Loss After Treatment of In-Stent Restenosis : An Intravascular Ultrasound Study

Avinoam Shiran, Gary S. Mintz, Ron Waksman, Roxana Mehran, Andrea Abizaid, Kenneth M. Kent, Augusto D. Pichard, Lowell F. Satler, Jeffrey J. Popma, and Martin B. Leon

Background-Mechanisms of recurrence after treatment of in-stent restenosis are unknown.

Methods and Results-We prospectively performed quantitative coronary angiography (QCA) and intravascular ultrasound (IVUS) in 37 lesions with Palmaz-Schatz stents enrolled in a study of intracoronary radiation for in-stent restenosis. Primary treatment was at the discretion of the operator: PTCA (n=8) or ablation-adjunct PTCA (n=29). Lesions were studied before intervention, immediately after primary intervention, and 42±8 minutes later. QCA measurements included minimal luminal diameter and diameter stenosis. Planar IVUS measurements included arterial, stent, lumen, and in-stent tissue areas. Stent, lumen, and in-stent tissue volumes were calculated by use of Simpson’s rule. Compared with
immediately after intervention, the delayed (42±8 minutes) minimal lumen area decreased by 20% (5.8±1.9 to 4.5±1.3 mm², P<0.0001) and the lumen volume by 12% (58±41 to 52±37 mm³, P=0.0001). Ten lesions (27%) had a≥2.0-mm² decrease in minimum lumen area. Lumen loss (1) resulted from increased tissue with the stent, (2) correlated with lesion length and preintervention in-stent tissue, and (3) was not seen angiographically.

Conclusions—There is significant tissue reintrusion shortly after catheter-based treatment of in-stent restenosis. This was greater in longer lesions and those with a larger in-stent tissue burden, was not reflected in the QCA measurements, and may contribute to recurrence.


Comparison of Aggressive Versus Nonaggressive Balloon Dilatation for Stent Deployment on Late Loss and Restenosis in Native Coronary Arteries

Steven L. Goldberg, MD, Carlo Di Mario, MD, Patrick Hall, MD,, Antonio Colombo, MD

Aggressive balloon dilatation is currently performed to assure full stent expansion and minimize the risk of stent thrombosis. It is not known if aggressive stent expansion leads to further increases in intimal proliferation and restenosis. A retrospective analysis was performed of 688 consecutive coronary narrowings in which stents were implanted. Angiographic follow-up was performed and quantitative coronary angiographic measurements were obtained using electronic calipers. Patients were divided into 2 groups. Group A (212 narrowings) had stents implanted before 1993, before the routine use of aggressive stent expansion techniques. Group B (476 narrowings) had stents implanted after 1993, when oversized balloons or high-pressure inflations were performed inside stents. Comparisons were made between angiographic changes and clinical outcomes between the 2 groups. Group B lesions had less favorable characteristics due to longer lengths of lesions. Despite this there was less angiographic and clinical restenosis in this cohort. There was no difference in late loss between the 2 groups. Thus, aggressive stent implantation techniques were not associated with increased late loss or restenosis.

The American Journal of Cardiology, 1998; 82:12:1437-1440

Direct stent implantation without predilatation using the multilink stent
The standard coronary stent implantation technique requires routine predilatation of the target lesion with a balloon catheter. In this study, we prospectively studied the feasibility and efficiency of elective coronary stent implantation without predilatation. In 94 patients who presented with various ischemic syndromes, direct implantation of 100 balloon expandable ACS MultiLink stents (7 over-the-wire, 93 rapid exchange) was attempted in 100 coronary lesions selected to have favorable characteristics. The stent crossed the lesion without predilatation in 97 cases (97%) and was successfully deployed in 93 (95.8%). In 4 patients, adjunctive high-pressure postdilatation was necessary to achieve optimal stent expansion. Reference vessel diameter was 3.12 ± 0.77 mm and lesion length 8.8 ± 2.7 mm. Minimal luminal diameter increased from 0.95 ± 0.38 mm to 2.98 ± 0.28 mm and diameter stenosis decreased from 71 ± 11% to 8 ± 11% after stenting. One occlusive dissection was treated by a second stent. There were no major in-hospital complications. At 1 month follow-up, 1 subacute thrombotic occlusion occurred. These results indicate that in a carefully selected coronary lesion subset, elective stent implantation without predilatation can be safely and effectively performed. The long-term results of this approach and possible advantages over the conventional implantation techniques remain unclear and need to be evaluated in further clinical studies.

The American Journal of Cardiology, 1998;82:12:1441-1444

Impact of an aggressive coronary stenting strategy on the incidence of target lesion revascularization

Ahmad Farshid, Roger M. Allan, Robert W. Giles, R. Michael McCredie, Mark R. Pitney, Warren F. Walsh

Coronary stenting has been shown to reduce the incidence of target lesion revascularization (TLR) compared with balloon angioplasty in highly selected patients. However, the impact of an aggressive coronary stenting strategy in unselected patients on the overall incidence of TLR is unclear. We assessed the effect of increased stenting by comparing long-term results in consecutive patients who underwent successful percutaneous revascularization (with or without stents) during June to December 1995 (n = 347) with those in June to December 1996 (n = 401). Stents were used in 22.5% of patients in 1995 versus 66.1% in 1996 (p <0.0001). Mean age of the patients was 62 ± 11 years (71% men) in 1995 versus 63 ± 10 in 1996 (76% men) (p = NS). The 2
groups were well matched with the exception that the 1996 cohort included more patients with unstable coronary syndromes (25% in 1995 vs 34% in 1996 (p = 0.003). There was no significant difference in the incidence of in-hospital adverse events. After 12 months of follow-up (complete in 95% of patients in each group), the incidence of TLR was significantly lower in the 1996 cohort than in the 1995 cohort (8.5% vs 14.7%, p = 0.0075). This was mainly due to reduced requirement for repeat angioplasty in 1996 patients compared with 1995 (6.5% vs 11.8%, p = 0.011). It is concluded that in an unselected patient population, an aggressive coronary stenting strategy was associated with a marked overall reduction in requirement for TLR over a 12-month period.


Effects of cilostazol on late lumen loss after Palmaz-Schatz stent implantation

Masao Yamasaki, Kazuhiro Hara, Yuji Ikari, Nobuyuki Kobayashi, Ken Kozuma, Yuki Ohmoto, Yoshio Oh-Hashi, Junya Ako, Hiroyoshi Nakajima, Noriyasu Chiku, Fumihiko Saeki, Tsutomu Tamura

Cilostazol inhibits intimal hyperplasia after stent implantation into canine iliac arteries. To determine the antiproliferative effect of this agent, cilostazol or aspirin was randomly given for 6 mo to 36 patients treated with Palmaz-Schatz stent implantation. Initial success was obtained in 34 patients. Repeat angiography was performed in 33 patients, and the complete angiographic data were obtained in 22 lesions of the cilostazol group and in 21 lesions of the aspirin group. The reference diameter and minimal luminal diameter were similar in both groups before and immediately after stent implantation. At follow-up, minimal luminal diameters were significantly greater in the cilostazol group than in the aspirin group. The reference diameter and minimal luminal diameter were similar in both groups before and immediately after stent implantation. At follow-up, minimal luminal diameters were significantly greater in the cilostazol group than in the aspirin group (P < 0.001). Late loss and loss index were significantly smaller in the cilostazol group than in the aspirin group (P < 0.001). These results suggest that cilostazol reduces angiographic late lumen loss and thereby may reduce the incidence of restenosis after Palmaz-Schatz stent implantation.


Direct coronary stenting without predilatation: A new therapeutic approach with a special balloon catheter
Coronary stenting is the primary therapeutic option for many coronary lesions, after the risk of subacute stent thrombosis and bleeding complications has been reduced by antithrombotic regimens and improved stent expansion. It would be desirable to shorten the procedure and the duration of ischemia, and to reduce the risk of ischemic complications during balloon inflation by implanting the stent without previous dilatation of the lesion. This is not possible with the presently available stent delivery systems. This new therapeutic concept was tested with a specially designed balloon catheter, on which slotted-tube stents can be fixed between two conical radiopaque markers. Sixty-one patients eligible for angioplasty underwent direct stent implantation without predilatation. Four procedures were performed for acute myocardial infarction, and two as high-risk PTCA. Single slotted-tube stents (Palmaz-Schatz, NIR, or JOSTent) of 14-16-mm length were mounted between the conical radiopaque markers of a special balloon which provided a fixation for the crimped stent. The direct implantation was successful in 80% of all patients, while in 10% the stent could be deployed after predilatation of the lesion. In 10% of lesions a stent could not be implanted with this and any other delivery system. When patients with successful direct stenting were compared with those with indirect (after predilatation) or unsuccessful stent deployment, the presence of angiographically visible calcification was higher in the unsuccessful cases (75% vs. 19%; P < 0.01), and the patients were older (72 ± 8 vs. 61 ± 12 years; P < 0.01). Radiation exposure time was only 8.7 ± 5.1 min as compared with 12.6 ± 7.6 min in conventional stent procedures with predilatation (P < 0.05). The number of balloons used per lesion was also lower than with conventional stenting. Stent dislocation was observed in 5%, and no embolization occurred. The new therapeutic approach of direct stenting without predilatation proved to be a safe and successful procedure in this initial series of coronary angioplasties. When calcified coronary lesions are avoided, it provides a way to rationalize stent implantation with shorter radiation exposure times, fewer balloons, and the potential advantage of fewer ischemic complications as no balloon predilatation is required.

Journal of the American College of Cardiology, 33:6:1619-1626

n-3 fatty acids do not prevent restenosis after coronary angioplasty: results from the CART study

Odd Johansen, Magne Brekke, Ingebjorg Seljeflot, Michael Abdelnoor, Harald Arnesen
The aim of the study was to investigate whether omega-3 fatty acids (n-3 FA) reduce the occurrence of restenosis after percutaneous transluminal coronary angioplasty.

**BACKGROUND**

Meta-analyses have shown significant reduction of restenosis after coronary angioplasty upon supplementation with n-3 FA.

**METHODS**

In a prospective, placebo-controlled, double-blind study, 500 patients were randomly allocated to treatment with n-3 FA (OmacorTM, Pronova AS, Oslo, Norway) 5.1 g/day or corn oil (placebo) starting at least two weeks prior to elective coronary angioplasty. The treatment was continued until restenosis evaluation by quantitative coronary angiography after six months. Stenosis was defined as a minimal luminal diameter (MLD) <40% of the reference diameter. Successful coronary angioplasty was defined as ≥20% acute gain in MLD and a residual stenosis <50%. Restenosis was defined as ≥20% late loss of diameter and stenosis >50% or an increase in stenosis of ≥0.7 mm. Three-hundred ninety-two patients fulfilled the criteria for initial stenosis and successful coronary angioplasty, and, except four patients who died, none were lost for follow-up.

**RESULTS**

Restenosis occurred in 108/266 (40.6%) of the treated stenoses in the Omacor group and in 93/263 (35.4%) in the placebo group (odds ratio [OR] 1.25, 95% confidence interval [CI] [0.87-1.80] p = 0.21). In the Omacor group one or more restenoses occurred in 90/196 (45.9%) patients as compared with 86/192 (44.8%) in the placebo group (OR 1.05, 95% CI [0.69-1.59] p = 0.82).

**CONCLUSIONS**

Supplementation with 5.1 g n-3 FA/day for six months, initiated at least two weeks prior to coronary angioplasty did not reduce the incidence of restenosis.

---

Circulation 1999;99: 44-52

Pathology of Acute and Chronic Coronary Stenting in Humans

Background—Despite the increasing use of stents, few reports have described human coronary artery morphology early and late after stenting.

Methods and Results—Histology was performed on 55 stents in 35 coronary vessels (32 native arteries and 3 vein grafts) from 32 patients. The mean duration of stent placement was 39±82 days. Fibrin, platelets, and neutrophils were associated with stent struts 11 days after deployment. In stents implanted for ≤3 days, only 3% of struts in contact with fibrous plaque had >20 associated inflammatory cells compared with 44% of struts embedded in a lipid core and 36% of struts in contact with damaged media (P<0.001). Neointimal growth determined late histological success, and increased neointimal growth correlated with increased stent size relative to the proximal reference lumen area. Neointimal thickness was greater for struts associated with medial damage than struts in contact with plaque (P<0.0001) or intact media (P<0.0001). When matched for time since treatment, neointimal cell density in stented arteries was similar to that in unstented arteries that had undergone balloon angioplasty and showed similar proteoglycan deposition.

Conclusions—Morphology after coronary stenting demonstrates early thrombus formation and acute inflammation followed by neointimal growth. Medial injury and lipid core penetration by struts result in increased inflammation. Neointima increases as the ratio of stent area to reference lumen area increases. Deployment strategies that reduce medial damage and avoid stent oversizing may lower the frequency of in-stent restenosis.

Journal of the American College of Cardiology, 32:2:305-310

Sustained benefit of stenting chronic coronary occlusion: long-term clinical follow-up of the Stenting in Chronic Coronary Occlusion (SICCO) study

Per Anton Sirnes, Svein Golf, Yngvar Myreng, Per Mo, Per Albertsson, Arild Mangschau, Knut Endresen, John Kjekshus

Objectives. This study assessed the long-term clinical outcome of stenting chronic occlusions.

Background. In the Stenting in Chronic Coronary Occlusion (SICCO) study, patients were randomized to additional stent implantation (n = 58) or not (n = 59) after successful recanalization and dilation of a chronic coronary occlusion. Palmaz-Schatz stents were used with full anticoagulation. The previously published 6-month angiographic follow-up results showed reduction of the restenosis rate from 74% to 32%.
Methods. The primary end point was the occurrence of major adverse cardiac events (cardiac death, lesion-related acute myocardial infarction, repeat lesion-related revascularization or angiographic documentation of reocclusion).

Results. Late clinical follow-up was obtained in all patients at 33 ± 6 months. Major adverse cardiac events occurred in 14 patients (24.1%) in the stent group compared with 35 patients (59.3%) in the percutaneous transluminal coronary angioplasty (PTCA) group (odds ratio 0.22, 95% confidence interval 0.10 to 0.49, p = 0.0002). Target vessel revascularization (including failed PTCA attempts) was performed in 24% of the stent group and in 53% of the PTCA group (p = 0.002). There were no events in the stent group after 8 months, whereas events continued to occur in the PTCA group. By multivariate analysis, allocation to the PTCA group, left anterior descending coronary artery lesion and lesion length were significantly related to the development of major adverse cardiac events.

Conclusions. These data demonstrate the long-term safety and clinical benefit of stenting recanalized chronic occlusions. There is a continued risk of late clinical events related to nonstented lesions. Implantation of an intracoronary stent should therefore be considered after successful opening of a chronic coronary occlusion.

Circulation 1999;99: 1011-1014

In-Stent Neointimal Proliferation Correlates With the Amount of Residual Plaque Burden Outside the Stent: An Intravascular Ultrasound Study

Francesco Prati, Carlo Di Mario, Issam Moussa, Bernhard Reimers, Maria Teresa Mallus, Antonio Parma, Ernesto Lioy, and Antonio Colombo

Background-The aim of this study was to evaluate the relationship between residual plaque burden after coronary stent implantation and the development of late in-stent neointimal proliferation.

Methods and Results-Between January 1996 and May 1997, 50 patients underwent intravascular ultrasound (IVUS) interrogation at 6±1.2 months after coronary stent implantation in native coronary arteries. IVUS images were acquired with a motorized pullback, and cross-sectional measurements were performed within the stents at 1-mm intervals. The following measurements were obtained: (1) lumen area (LA), (2) stent area (SA), (3) area delimited by the external elastic membrane (EEMA), (4) percent neointimal area calculated as (SA-LA/SA)x100, and (5) percent residual plaque area calculated as (EEMA-SA)/EEMAx100. Volume measurements within the stented segments were calculated by applying Simpson’s rule. In the pooled data
analysis of 876 cross sections, linear regression showed a significant positive correlation between percent residual plaque area and percent neointimal area \((r=0.50, y= 45.03+0.29x, P<0.01)\). There was significant incremental increase in mean percent neointimal area for stepwise increase in percent residual plaque area. Mean percent neointimal area was 16.3±10.3% for lesions with a percent residual plaque area of ≥50% and 27.7±11% for lesions with a percent residual plaque area of 50% \((P<0.001)\). The volumetric analysis showed that the percent residual plaque volume was significantly greater in restenotic lesions compared with nonrestenotic lesions \((58.7±4.3\% \text{ versus } 51.4±5.7\%, \text{ respectively}; P<0.01)\).

Conclusions-Late in-stent neointimal proliferation has a direct correlation with the amount of residual plaque burden after coronary stent implantation, supporting the hypothesis that plaque removal before stent implantation may reduce restenosis.

Circulation 1999;99: 248-253

Safety and Efficacy of Ticlopidine for Only 2 Weeks After Successful Intracoronary Stent Placement

Peter B. Berger, Malcolm R. Bell, David Hasdai, Diane E. Grill, Steve Melby, and David R. Holmes, Jr

Background-In patients receiving intracoronary stents, stent thrombosis is reduced when ticlopidine therapy is combined with aspirin after the procedure. However, ticlopidine causes neutropenia in 1% of patients when administered for ≥2 weeks, and little is known about the duration that ticlopidine needs be administered to prevent stent thrombosis.

Methods and Results-We analyzed 827 patients undergoing successful stent placement in 1061 coronary segments at Mayo Clinic who were treated between May 1, 1996, and October 31, 1997. Chronic warfarin therapy, cardiogenic shock, and enrollment in research protocols requiring 4 weeks of ticlopidine were exclusion criteria; ticlopidine was discontinued after 14 days in all remaining patients. The mean age of the study population was 64±11 years; 49% had suffered a prior infarction, 20% had undergone coronary artery bypass surgery, and 65% had multivessel disease. The indication for stent placement was dissection or abrupt closure in 31% of patients and suboptimal results from balloon angioplasty in 18%. Placement was elective in 51% of patients, and 10.3% of patients were treated within 12 hours of an acute myocardial infarction. Mean nominal stent size was 3.3±0.5 mm. High-pressure inflations \((≥12 \text{ atm})\) were performed in all patients (mean, 17±4 atm). Intravascular ultrasound was used to facilitate stent placement in 8.8% of patients. Abciximab was administered to 38% of patients; 11% of patients who were at increased risk of stent thrombosis were treated
with enoxaparin for 10 to 14 days. Adverse cardiovascular events in the 14 days after stent placement occurred in 11 patients (1.3%). Two patients died of nonischemic causes (sepsis and renal failure) in the 15th through 30th days after ticlopidine was stopped. However, there were no cardiovascular deaths, myocardial infarctions, coronary artery bypass operations, or repeat angioplasty procedures between the 15th and 30th days; stent thrombosis did not occur in any patient after ticlopidine had been stopped. No patient developed neutropenia, although 1.8% of the first 489 patients who were closely monitored for side effects from ticlopidine developed side effects requiring its discontinuation, and milder side effects occurred in 4.7%.

Conclusions-In patients receiving intracoronary stents, the discontinuation of ticlopidine therapy 14 days after stent placement is associated with a very low frequency of stent thrombosis and other adverse events.

The American Journal of Cardiology, 83:5:681-686

Predictors of long-term outcome after stent implantation in a saphenous vein graft

Michel R. Le May, Marino Labinaz, Jean-Francois Marquis, Louise A. Laramee, Edward R. O’Brien, William L. Williams, Jennifer L. Jelley, Kirsten Woodend, Lyall A. Higginson

Stenting of saphenous vein graft (SVG) lesions is associated with significant clinical events at late follow-up. We sought to determine predictors of clinical outcome after this procedure. One hundred twenty-eight balloon-expandable stents were implanted in the SVGs of 106 patients. Baseline clinical and angiographic characteristics were analyzed. All grafts, including those not stented, were scored for extent of disease involving the luminal surface of the graft, and for the presence of low profile lesions (<50% graft stenosis) and/or high profile lesions (≥50% graft stenosis). The in-hospital success rate was 98.1%. Before discharge, no patient died, required bypass surgery, or had repeat angioplasty of the same graft. Follow-up was obtained on all the patients. At a median of 18 months, 15% had died, 17% had experienced myocardial infarction, 20% had required repeat bypass surgery, and 37% needed repeat angioplasty to either the same site or a different lesion. Event-free survival was recorded in only 44% of the patients. The cumulative Kaplan-Meier survival at 2.4 years was 78.7%. Using the Cox proportional hazards model, predictors of survival were the absence of a high profile lesion in any nonstented patent graft (p = 0.004), and the use of lipid-lowering agents at follow-up (p = 0.01). Stenting SVG lesions can be performed with a high degree of procedural success, but at long-term follow-up there is a high rate of cardiac events. The absence of a high profile lesion in any nonstented patent graft is the strongest predictor of survival.
Background-Although intravascular ultrasound (IVUS) is the present standard for the evaluation of optimum stent deployment, this technique is expensive and not routinely feasible in most catheterization laboratories. Coronary pressure-derived myocardial fractional flow reserve (FFRmyo) is an easy, cheap, and rapidly obtainable index that is specific for the conductance of the epicardial coronary artery. In this study, we investigated the usefulness of coronary pressure measurement to predict optimum and suboptimum stent deployment.

Methods and Results-In 30 patients, a Wiktor-i stent was implanted at different inflation pressures, starting at 6 atm and increasing step by step to 8, 10, 12, and 14 atm, if necessary. After every step, stent deployment was evaluated by quantitative coronary angiography (QCA), IVUS, and coronary pressure measurement. If any of the 3 techniques did not yield an optimum result, the next inflation was performed, and all 3 investigational modalities were repeated until optimum stent deployment was present by all of them or until the treating physician decided to accept the result. Optimum deployment according to QCA was finally achieved in 24 patients, according to IVUS in 17 patients, and also according to coronary pressure measurement in 17 patients. During the step-up, a total of 81 paired IVUS and coronary pressure measurements were performed, of which 91% yielded concordant results (ie, either an optimum or a suboptimum expansion of the stent by both techniques, P<0.00001). On the contrary, QCA showed a low concordance rate with IVUS and FFRmyo (48% and 46%, respectively).

Conclusions-In this study, using a coil stent, both IVUS and coronary pressure measurement were of similar value with respect to the assessment of optimum stent deployment. Therefore, coronary pressure measurement can be used as a cheap and rapid alternative to IVUS for that purpose.
and Clinical Outcome After Coronary Stent Placement

Adnan Kastrati, Albert Schomig, Shpend Elezi, Josef Dirschinger, Julinda Mehilli, Helmut Schuhlen, Rudolf Blasini, and Franz-Josef Neumann

Background-The modified American College of Cardiology/American Heart Association (ACC/AHA) lesion morphology criteria are predictive of early outcome after various coronary catheter interventions. Their potential prognostic value after stent implantation and, in particular, for restenosis and long-term clinical outcome has not been studied. We assessed the prognostic value of the modified ACC/AHA criteria for the long-term angiographic and clinical outcome of patients after coronary stenting.

Methods and Results-This study includes 2944 consecutive patients with symptomatic coronary artery disease treated with coronary stent placement. Modified ACC/AHA lesion morphology criteria were used to qualitatively assess the angiograms; type A and B1 lesions were categorized as simple, and type B2 and C lesions were designated complex. Primary end points were angiographic restenosis and 1-year event-free survival. Restenosis rate was 33.2% in complex lesions and 24.9% in simple lesions (P<0.001). It was 21.7% for type A, 26.3% for type B1, 33.7% for type B2, and 32.6% for type C lesions. One-year event-free survival was 75.6% for patients with complex lesions and 81.1% for patients with simple lesions (P<0.001). It was 85.2% for patients with type A, 79.4% for type B1, 75.9% for type B2, and 75.2% type C lesions. The higher risk for restenosis and an adverse outcome associated with complex lesions was also maintained after multivariate adjustment for other clinical and angiographic characteristics.

Conclusions-The modified ACC/AHA lesion morphology scheme has significant prognostic value for the outcome of patients after coronary stent placement. Lesion morphology is able to influence the restenosis process and thus the entire 1-year clinical course of these patients.


Pathology of Acute and Chronic Coronary Stenting in Humans

Background—Despite the increasing use of stents, few reports have described human coronary artery morphology early and late after stenting.

Methods and Results—Histology was performed on 55 stents in 35 coronary vessels (32 native arteries and 3 vein grafts) from 32 patients. The mean duration of stent placement was $39 \pm 82$ days. Fibrin, platelets, and neutrophils were associated with stent struts ≤11 days after deployment. In stents implanted for 3 days, only 3% of struts in contact with fibrous plaque had >20 associated inflammatory cells compared with 44% of struts embedded in a lipid core and 36% of struts in contact with damaged media (P<0.001). Neointimal growth determined late histological success, and increased neointimal growth correlated with increased stent size relative to the proximal reference lumen area. Neointimal thickness was greater for struts associated with medial damage than struts in contact with plaque (P<0.0001) or intact media (P<0.0001). When matched for time since treatment, neointimal cell density in stented arteries was similar to that in unstented arteries that had undergone balloon angioplasty and showed similar proteoglycan deposition.

Conclusions—Morphology after coronary stenting demonstrates early thrombus formation and acute inflammation followed by neointimal growth. Medial injury and lipid core penetration by struts result in increased inflammation. Neointima increases as the ratio of stent area to reference lumen area increases. Deployment strategies that reduce medial damage and avoid stent oversizing may lower the frequency of in-stent restenosis.

Circulation 1998;98: 1172-1177

Plasma Lipoprotein(a) Is Not a Predictor for Restenosis After Elective High-Pressure Coronary Stenting

Flavio Ribichini, Giuseppe Steffenino, Antonio Dellavalle, Antonello Vado, Valeria Ferrero, Terenzio Camilla, Silvia Giubergia, and Eugenio Uslenghi

Background—Lipoprotein(a) is a risk factor for coronary artery disease. Although it has been implicated in restenosis after balloon angioplasty, its role in restenosis within coronary stents is unknown. The aim of the study was to assess the role of plasma lipoprotein(a) as a predictor for restenosis after elective coronary stenting.

Methods and Results—Elective, high-pressure stenting of de novo lesions in native coronary arteries with Palmaz-Schatz stents was performed in 325 consecutive patients. Clinical, angiographic, and biochemical data
were analyzed prospectively. Angiographic follow-up was performed at 6 months. Lipoprotein(a) levels were compared in patients with and without restenosis. Angiographic follow-up was obtained in 312 patients (96%); recurrence was observed in 67 patients (21.5%). No clinical or biochemical variable was associated with restenosis. Lipoprotein(a) level was 37.81±49.01 mg/dL (median, 22 mg/dL; range, 3 to 262 mg/dL) in restenotic patients and 36.95±40.65 mg/dL (median, 22 mg/dL; range, 0 to 244 mg/dL) in nonrestenotic patients (P=NS). The correlations between percent diameter stenosis, minimum luminal diameter, and late loss at follow-up angiography and basal lipoprotein(a) plasma level after logarithmic transformation were 0.006, 0.002, and 0.0017, respectively. Multiple stents were associated with a higher incidence of restenosis (P=0.006), but biochemical data in these patients were similar to those treated with single stents.

Conclusions-The basal plasma level of lipoprotein(a) measured before the procedure is not a predictor for restenosis after elective high-pressure coronary stenting.

The American Journal of Cardiology, 1998;83:4:502-506

Immediate results and late clinical outcomes after new crossflex coronary stent implantation

Seung-Jung Park, Seong-Wook Park, Cheol Whan Lee, Myeong-Ki Hong, Jae-Joong Kim, Hoon-Ki Park, Mun K. Hong, Gary S. Mintz, Martin B. Leon

This study evaluates the safety and efficacy of the new CrossFlex stent in the treatment of native coronary artery disease. The CrossFlex stent is a flexible, balloon-expandable new device with an excellent flexibility, radial strength, conformability, and radio-opacity. Little data are available concerning the clinical and angiographic outcomes of this device. The CrossFlex stent was implanted in 209 consecutive patients with 226 lesions. Follow-up angiography was performed at 6 months, and clinical evaluation was undertaken at regular intervals after stent implantation. Procedural success was achieved in all lesions without in-hospital complications. Angiographic follow-up data were available in 153 of the 187 eligible lesions (follow-up rate, 82%), and the overall angiographic restenosis rate was 16.3%. Minimal lumen diameter immediately after stent placement was the only predictor of angiographic restenosis. Clinical follow-up was obtained in all patients at 10.5 ± 5.2 months. There were 4 deaths (1 cardiac in origin, the others noncardiac in origin), and 1 nonfatal myocardial infarction (nonstented artery) during follow-up. Target lesion revascularization was required in 15 patients (7%), and the overall event-free survival rate (death, myocardial infarction, and repeat revascularization) was 87% at the end of the follow-up period. The CrossFlex stent is a safe and effective device
with a high procedural success rate, and a favorable late clinical outcome for treatment of native coronary artery disease. Further randomized trials are needed to compare the CrossFlex stent with standard slotted-tube stents.


Acute Platelet Inhibition With Abciximab Does Not Reduce In-Stent Restenosis (ERASER Study)

The ERASER Investigators

Background
Although stents reduce restenosis compared with balloon angioplasty, their long-term efficacy is limited by neointimal hyperplasia. Platelet and \( \alpha v \beta 3 \) integrin receptor inhibition limits neointimal proliferation in animal models of arterial injury.

Methods and Results
We tested whether the dual \( \beta 3 \) integrin blocking agent abciximab, administered for 12 or 24 hours at the same intravenous dose as that shown to reduce adverse clinical events (death, infarction, and revascularization) after angioplasty, would reduce restenotic tissue volume, as measured by intravascular ultrasound at 6 months. Two hundred twenty-five patients were randomly allocated to placebo or abciximab before coronary intervention. Of the 215 patients who received stents and study drug, 191 (88.8%) returned for late (≥4 months) coronary evaluation. Tissue volume, expressed as a percentage of stent volume, did not differ: 25±15%, 27±15%, and 29±14% for the patients in the placebo and the 12- and 24-hour abciximab groups, respectively. Lack of abciximab benefit was confirmed by quantitative coronary angiography (dichotomous restenosis: 11.6%, 18.9%, and 19.4%; loss index: 0.33, 0.52, and 0.47, respectively, P=NS).

Conclusions
Potent platelet inhibition with abciximab, as administered in this study, does not reduce in-stent restenosis. The interrelationship between stents, platelets, and neointimal proliferation requires further study.

Am J Cardiol 1999 Dec 1;84(11):1317-22
Intracoronary serotonin release after high-pressure coronary stenting.


It is known that platelet-derived serotonin at the site of coronary angioplasty induces an increase in coronary tone and plays a role in vasoconstriction after balloon angioplasty. The goal of the present investigation was to compare local release of serotonin with changes in coronary tone after coronary stenting and coronary angioplasty. Twenty patients with significant stenosis (> or =50% diameter narrowing) of the left anterior descending coronary artery were referred to traditional coronary angioplasty (10 patients; group 1) or high-pressure coronary stenting (10 patients; group 2). An additional 16 patients with similar angiographic characteristics were referred to the coronary angioplasty group (8 patients; group 1a) or stenting group (8 patients; group 2a) after pretreatment with ketanserin. Serotonin plasma levels in coronary sinus and coronary cross-sectional area distal to the site of dilatation were measured before and after bath revascularization procedures. In groups 1 and 1a, plasma serotonin levels in coronary sinus increased from basal values of 3.2+/−0.8 and 3.2+/−0.5 ng/ml to 29.5+/−13 and 25.6+/−9 ng/ml after ballooning (p <0.001 vs baseline). In groups 2 and 2a, plasma serotonin levels in coronary sinus increased from basal values of 3.5+/−0.3 and 3.5+/−0.7 ng/ml to 114.6+/−34 and 113+/−29 ng/ml after stenting (p <0.001 vs baseline and vs postangioplasty values in groups 1 and 1a). Coronary cross-sectional area distal to the site of dilatation significantly decreased after angioplasty in group 1 (from 4.33+/−0.4 to 3.32+/−0.3 mm2; p <0.001), and after stenting in group 2 (from 4.27+/−0.3 to 2.86+/−0.2 mm2; p <0.001 vs baseline, and p <0.02 vs values after coronary angioplasty in group 1). Pretreatment with ketanserin significantly reduced distal coronary vasoconstriction after angioplasty and stenting. It is concluded that the higher local serotonin release after coronary stenting may explain the more marked coronary constriction observed after prosthesis deployment with respect to traditional coronary angioplasty. Ketanserin is able to significantly attenuate the increase in distal coronary tone induced by both revascularization procedures.

Figure. Cross-sectional area distal to the site of dilatation at different steps of coronary angioplasty and stenting with and without pretreatment with ketanserin. Both revascularization procedures were associated with a significant vasoconstriction of coronary segments distal to the site of dilatation. Coronary stenting induced a more marked increase in coronary vasotone than that observed after coronary angioplasty (p <0.02). Ketanserin reduced distal coronary vasoconstriction after angioplasty and stenting (p <0.01).
Direct coronary stenting without predilation.


OBJECTIVES: Coronary stenting is the primary therapeutic option for percutaneous treatment of many coronary lesions, after the risk of subacute stent thrombosis and bleeding complications has been reduced by improved antithrombotic regimens and high pressure stent expansion. BACKGROUND: Direct stent implantation (without predilation) has been considered a promising new technique that may reduce the procedure time, radiation exposure time and cost. METHODS: After having reviewed all cases of stent implantation from February to June 1998 (n = 585), 185 (32%) of these patients were retrospectively considered candidates for direct stent implantation without predilation, according to prespecified criteria (i.e., absence of severe coronary calcifications and/or tortuosity of the lesion or the segment proximal to the lesion). By operator preference, direct coronary stent implantation was actually attempted in 123 (21%) of the 585 patients (100 men, 60 +/- 10 years old) on 123 lesions. The impact of direct stenting in terms of cost, procedure time, radiation exposure time and amount of contrast dye used was assessed by comparing the two groups of patients who underwent single-vessel stenting without (n = 69) and with (n = 46) predilation. RESULTS: Direct stenting was successful in 118 patients (96%). No acute or subacute complications occurred in these patients. Procedure time, radiation exposure time and cost were significantly lower in the group of patients who had single-vessel direct versus conventional stenting (45 +/- 31 vs. 64 +/- 46 min, 12 +/- 9 vs. 16 +/- 10 min and 1,305 +/- 363 vs. 2,210 +/- 803 Euro, respectively; p < 0.05 for all). CONCLUSIONS: Direct stenting without predilation in selected lesions seems to be a safe and successful procedure that provides a way to contain cost and to shorten radiation exposure time.

Summary
1. Success rate of direct stenting: 96%
2. No acute or subacute complications
3. Lower procedure time, radiation exposure time and cost: 45 +/- 31 vs. 64 +/- 46 min, 12 +/- 9 vs. 16 +/- 10 min and 1,305 +/- 363 vs. 2,210 +/- 803 Euro, respectively (p < 0.05 for all).

J Am Coll Cardiol 1999 Nov 15;34(6):1675-9
OBJECTIVES: We assessed the endothelial-dependent vasomotor function in nonrestenotic coronary arteries more than six months following stent implantation, balloon angioplasty (BA), and directional atherectomy (DCA). BACKGROUND: Catheter-based coronary interventions are associated with extensive arterial injury. Endothelial function has been shown to remain chronically abnormal after vascular injury. The long-term effects of different percutaneous coronary interventions on endothelial function are not known. METHODS: Thirty-nine patients treated at least six months earlier with a coronary intervention for isolated proximal left anterior descending (LAD) stenosis, with no evidence of restenosis, were studied. Twelve patients had been stented, 15 had been treated with BA, and 12 had undergone DCA. Changes in diameter of the intervened LAD, and the unintervened circumflex coronary artery (Cx), in response to intracoronary acetylcholine infusions were assessed by quantitative angiography. RESULTS: The groups had similar angiographic characteristics and risk factors for endothelial dysfunction. The LAD constricted significantly more (p = 0.02) in previously stented patients (-21.8+/−4.3%), as compared to patients previously treated with BA (-9.5+/−2.8%) or with DCA (-9.1+/−3.6%). In contrast, acetylcholine infusion resulted in mild constriction in the Cx, which was similar in the three groups (p = 0.47). By multiple regression analysis, previous implant of a stent was the only significant predictor of LAD constriction (p = 0.008). CONCLUSIONS: More severe endothelial dysfunction was observed long term after stenting as compared to BA or DCA. These findings may have implications with respect to the progression of atherosclerosis in coronary arteries subjected to percutaneous interventions.

Figure. Percent change in mean luminal diameter of the left anterior descending coronary artery (A) and circumflex artery (B) from baseline, in response to intracoronary acetylcholine infusion. *p = 0.02 versus balloon angioplasty and directional atherectomy groups. Open triangle = Stent group. Closed circle = Balloon angioplasty group. Open square = Directional atherectomy group.

J Am Coll Cardiol 1999 Nov 1;34(5):1498-506

Randomized comparison of coronary stent implantation and balloon angioplasty in the treatment of de novo coronary artery lesions (START): a four-year follow-up.
OBJECTIVE: The purpose of this study was to test the hypothesis that stent implantation in de novo coronary artery lesions would result in lower restenosis rates and better long-term clinical outcomes than balloon angioplasty. BACKGROUND: Placement of an intracoronary stent, as compared with balloon angioplasty, has proven to reduce the rate of restenosis. However, the long-term clinical benefit of stenting over angioplasty has not been assessed in large randomized trials. METHODS: We randomly assigned 452 patients with either stable (129 patients) or unstable (323 patients) angina pectoris to elective stent implantation (229 patients) or standard balloon angioplasty (223 patients). Coronary angiography was performed at baseline, immediately after the procedure and six months later. End points were the rate of restenosis at six months and a composite of death, myocardial infarction (MI) and target vessel revascularization over four years of follow-up. RESULTS: Procedural success rate was achieved in 84% and 95% (balloon angioplasty vs. stent, respectively). The increase in the minimal luminal diameter was greater in the stent group both after the intervention (2.02 +/- 0.6 mm vs. 1.43 +/- 0.6 mm in the angioplasty group; p < 0.0001), and at six-month follow-up (1.98 +/- 0.7 mm vs. 1.63 +/- 0.7 mm; p < 0.001). The corresponding restenosis rates were 22% and 37%, respectively (p < 0.002). After four years, no differences in mortality (2.7% vs. 2.4%) and nonfatal MI (2.2% vs. 2.8%) were found between the stent and the angioplasty groups, respectively. However, the requirement for further revascularization procedures of the target lesions was significantly reduced in the stent group (12% vs. 25% in the angioplasty group; relative risk 0.49, 95% confidence interval 0.32 to 0.75, p = 0.0006); most of the repeat procedures (84%) were carried out within six months of entry into the study. CONCLUSIONS: Patients who received an intracoronary stent showed a lower rate of restenosis than those treated with conventional balloon angioplasty. The benefit of stenting was maintained four years after implantation, as manifested by a significant reduction in the need for repeat revascularization.

Summary

Circulation 1999 Nov 2;100(18):1872-8


BACKGROUND: The angiographic presentation of in-stent restenosis (ISR) may convey prognostic information on subsequent target vessel revascularizations (TLR). METHODS AND RESULTS: We developed an angiographic classification of ISR according to the geographic distribution of intimal hyperplasia in reference to the implanted stent. Pattern I includes focal (< or =10 mm in length) lesions, pattern II is ISR>10 mm within the stent, pattern III includes ISR>10 mm extending outside the stent, and pattern IV is totally occluded ISR. We classified a total of 288 ISR lesions in 245 patients and verified the angiographic accuracy of the classification by intravascular ultrasound. Pattern I was found in 42% of patients, pattern II in 21%, pattern III in 30%, and pattern IV in 7%. Previously recurrent ISR was more frequent with increasing grades of classification (9%, 20%, 34%, and 50% for classes I to IV, respectively; P=0.0001), as was diabetes (28%, 32%, 39%, and 48% in classes I to IV, respectively; P<0.01). Angioplasty and stenting were used predominantly in classes I and II, whereas classes III and IV were treated with atheroablation. Final diameter stenosis ranged between 21% and 28% (P=NS among ISR patterns). TLR increased with increasing ISR class; it was 19%, 35%, 50%, and 83% in classes I to IV, respectively (P<0.001). Multivariate analysis showed that diabetes (odds ratio, 2.8), previously recurrent ISR (odds ratio, 2.7), and ISR class (odds ratio, 1.7) were independent predictors of TLR. CONCLUSIONS: The introduced angiographic classification is prognostically important, and it may be used for appropriate and early patient triage for clinical and investigational purposes.

* p<0.0001


Periprocedural quantitative coronary angiography after Palmaz-Schatz stent implantation predicts the restenosis rate at six months: results of a meta-analysis of the BElgian NEtherlands Stent study (BENESTENT) I, BENESTENT II Pilot, BENESTENT II and MUSIC trials. Multicenter Ultrasound Stent In Coronaries.

Serruys PW, Kay IP, Disco C, Deshpande NV, de Feyter PJ

OBJECTIVES: We aimed to identify periprocedural quantitative coronary angiographic (QCA) variables that have predictive value on long-term angiographic results and to construct multivariate models using these variables for postprocedural prognosis. BACKGROUND: Coronary stent implantation has reduced the restenosis rate significantly as compared with balloon angioplasty in short de novo lesions in coronary arteries >3 mm in size. Although the postprocedural minimal luminal diameter (MLD) is known to have significant
bearing on long-term angiographic results, no practically useful model exists for prediction of angiographic outcome based on the periprocedural QCA variables. METHODS: The QCA data from patients who underwent Palmaz-Schatz stent implantation for short (<15 mm) de novo lesions in coronary arteries ≥3 mm and completed six months of angiographic follow-up in the four prospective clinical trials (BENESTENT I, BENESTENT II pilot, BENESTENT II and MUSIC) were pooled. Multiple models were constructed using multivariate analysis. The Hosmer-Lemeshow goodness-of-fit test was used to identify the model of best fit, and this model was used to construct a reference chart for prediction of angiographic outcome on the basis of periprocedural QCA variables. RESULTS: Univariate analysis performed using QCA variables revealed that vessel size, MLD before and after the procedure, reference area before and after the procedure, minimal luminal cross-sectional area before and after the procedure, diameter stenosis after the procedure, area of plaque after the procedure and area stenosis after the procedure were significant predictors of angiographic outcome. Using multivariate analysis, the Hosmer-Lemeshow goodness-of-fit test showed that the model containing percent diameter stenosis after the procedure and vessel size best fit the data. A reference chart was then developed to calculate the expected restenosis rate. CONCLUSIONS: Restenosis rate after stent implantation for short lesions can be predicted using the variables percent diameter stenosis after the procedure and vessel size. This meta-analysis indicates that the concept of “the bigger the better” holds true for coronary stent implantation. Applicability of the model beyond short lesions should be tested.

Summary
1. Predictors of angiographic outcome by univariate analysis: vessel size, MLD before and after the procedure, reference area before and after the procedure, minimal luminal cross-sectional area before and after the procedure, diameter stenosis after the procedure, area of plaque after the procedure and area stenosis after the procedure
2. By multivariate analysis: percent diameter stenosis after the procedure and vessel size

Am J Cardiol 1999 Oct 1;84(7):789-94

Baseline clinical and angiographic variables associated with long-term outcome after successful intracoronary stent implantation.

Mathew V, Grill DE, Scott CG, Garratt KN, Holmes DR Jr

Although randomized studies have demonstrated improved outcomes with stents over balloon angioplasty in
straightforward coronary narrowings in low-risk patients, this advantage is less clear for complex lesions and high-risk patients. This study was designed to identify clinical and angiographic variables that are associated with long-term outcome after stent implantation. We identified 1,709 patients undergoing successful stent placement without in-hospital major adverse events. We analyzed clinical, lesional, and procedural variables to determine their correlation with outcome. Mean duration of follow-up was 1.6 +/- 1.4 years. Cox proportional-hazards models and stepwise methods were used to assess which covariates were potentially related to each end point. The occurrence of death/myocardial infarction (MI) was associated with any history of congestive heart failure (relative risk [RR] 3.3, 95% confidence interval [CI] 2.3 to 4.7, p <0.0001), procedure within 24 hours of MI (RR 2.3, CI 1.3 to 4.1, p = 0.0048), vein graft intervention (RR 1.8, CI 1.3 to 2.6, p = 0.0007), and prior MI (RR 1.8, CI 1.2 to 2.6, p = 0.004). Repeat revascularization was associated with multivessel stent placement (RR 1.8, CI 1.2 to 2.8, p = 0.006) and stent for abrupt closure (RR 1.7, CF 1.1 to 2.7, p = 0.03), but was less frequent with de novo lesions and right coronary artery lesions (RR 0.6, CI 0.5 to 0.8, p = 0.0007, and RR 0.8, CI 0.6 to 1.0, p = 0.05, respectively). The cumulative end point of death,MI,repeat revascularization was associated with congestive heart failure (RR 1.7, CI 1.3 to 2.2, p <0.0001), multivessel stent placement (RR 1.6, CI 1.1 to 2.3, p = 0.03), warfarin therapy (RR 1.4, CI 1.2 to 1.8, p = 0.001), and procedure within 24 hours of MI (RR 1.5, CI 1.1 to 2.1, p = 0.02), but was less frequent with complete revascularization and right coronary artery intervention (RR 0.8, CI 0.7 to 0.99, p = 0.04, and RR 0.7, CI 0.6 to 0.9, p = 0.009, respectively). Thus, this study demonstrates that there are readily identifiable characteristics in patients treated successfully with stents that are associated with long-term outcome.

Summary
1. Parameters associated with death,MI: history of congestive heart failure (RR 3.3, p <0.0001), procedure within 24 hours of MI (RR 2.3, p = 0.0048), vein graft intervention (RR 1.8, p = 0.0007), and prior MI (RR 1.8, p = 0.004).
2. Parameters associated with repeat revascularization: multivessel stent placement (RR 1.8, p = 0.006) and stent for abrupt closure (RR 1.7, p = 0.03), de novo lesions(RR 0.6, p = 0.0007), RCA lesions(RR 0.8, p = 0.05).
3. Parameters associated with cumulative end point of death,MI,repeat revascularization: CHF (RR 1.7, p <0.0001), multivessel stent placement (RR 1.6, p = 0.03), warfarin therapy (RR 1.4, p = 0.001), procedure within 24 hours of MI (RR 1.5, p = 0.02), complete revascularization(RR 0.8, p = 0.04), RCA intervention (RR 0.7, p = 0.009).

Am J Cardiol 1999 Sep 15;84(6):644-9

Short- and long-term outcomes of Wiktor stent implantation at low versus high pressures. Austrian Wiktor Stent Study Group.

A prospective, randomized, multicenter trial was conducted to evaluate whether high-pressure postdilation of the Wiktor stent provides short- and long-term benefits compared with the conventional low-pressure implantation technique. From June 1995 through May 1996, 181 patients were randomly assigned to either low-pressure (6 to 12 atm, group A, n = 94) Wiktor stent placement or to high-pressure postdilation (> or = 13 atm, group B, n = 87) after stent deployment. All patients were followed up clinically for 7 +/- 3 months, with an angiographic follow-up in 154 patients (85%). After stent implantation, neither minimal lumen diameter (MLD) nor percent diameter stenosis (%DS) differed significantly between the 2 groups (MLD, 2.8 +/- 0.5 vs 2.9 +/- 0.5 mm; %DS, 17 +/- 8% vs 16 +/- 9% for groups A and B, respectively). However, a trend toward a larger mean lumen diameter within the stent was observed in group B (3.3 +/- 0.6 vs 3.5 +/- 0.5 mm for groups A and B, respectively; difference between means 0.14 mm, 95% confidence interval -0.01 to 0.29, p = 0.08). Angiographic follow-up revealed similar MLD and %DS in both treatment groups (MLD, 2.1 +/- 0.7 vs 2.2 +/- 0.8 mm; %DS, 31 +/- 17% vs 30 +/- 24% for groups A and B, respectively, p = NS). Acute stent thrombosis occurred in 2 patients (1%) (1 patient in each group), and subacute thrombosis in 1 patient (0.6%) in group A. There was 1 death in group A, and target lesion restenosis (> or = 50% DS) was observed in 15% of patients with no differences between the groups. In conclusion, this study demonstrated favorable short- and long-term results of Wiktor stent implantation. Despite a trend toward additional initial lumen gain by high-pressure postdilation, this did not translate into a measurable improvement in long-term outcome.

Summary

J Am Coll Cardiol 1999 Sep;34(3):698-706

Acute and nine-month clinical outcomes after “suboptimal” coronary stenting: results from the STent Anti-thrombotic Regimen Study (STARS) registry.

OBJECTIVES: This registry collected the 30-day and 9-month clinical outcomes of patients whose coronary stent implantation was suboptimal, and compared them with the cohort of patients with “optimal” stenting in the randomized portion of the STent Anti-thrombotic Regimen Study (STARS) trial. BACKGROUND: Although “optimal” stenting combined with an aspirin and ticlopidine regimen carries a low (0.5%) incidence of subacute stent thrombosis, only limited data are available for patients in whom stents are deployed suboptimally. METHODS: In the STARS, 312 (15.9%) of 1,965 patients enrolled were excluded from participation in the randomized trial based on a perceived “suboptimal” result of coronary stenting. Of these, 265 patients met prespecified criteria for suboptimal stenting, and were followed in a parallel registry, which was compared with the randomized STARS optimal stenting cohort. The primary end point was a 30-day composite of death, emergent target lesion revascularization, angiographic thrombosis of the target vessel without revascularization and nonfatal myocardial infarction (MI) unrelated to direct procedural complications. RESULTS: Registry patients had a similar frequency of the primary end point compared with the overall randomized cohort (3.0% vs. 2.2%), with this end point correlating to use of multiple stents, smaller final lumen diameter and absence of ticlopidine from the poststent regimen. Overall 30-day mortality (1.1% vs. 0.06%, p = 0.009) and periprocedural non-Q wave MI (8.7% vs. 4.2%, p = 0.003) were more frequent in registry patients, and appeared to be related to acute procedural complications. Clinical restenosis was significantly higher for registry patients (26.8% vs. 16.0%, p = 0.001), relating to greater prevalence of independent predictors such as smaller final lumen diameter and multiple stent use. CONCLUSIONS: In the STARS registry, the inability to perform optimal stenting correlated with smaller final lumen diameter and longer stent length. With ticlopidine-containing regimens, the acute clinical results of “suboptimal” stent deployment are clinically acceptable, although they are not quite as good as those of optimal stenting using similar drug therapy.

Summary

J Am Coll Cardiol 1999 Sep;34(3):651-9

Stented segment length as an independent predictor of restenosis.

Kobayashi Y, De Gregorio J, Kobayashi N, Akiyama T, Reimers B, Finci L, Di Mario C, Colombo A
OBJECTIVES: We sought to evaluate the relation between stented segment length and restenosis. BACKGROUND: Multiple or long coronary stents are now being implanted in long lesions or in tandem lesions. A longer stented segment might result in a higher probability of restenosis. However, there is little information available on the relation between stented segment length and restenosis. METHODS: Between April 1995 and December 1996, 725 patients with 1,090 lesions underwent stenting. Lesions were divided into three groups according to the length of the stented segment: 1) group I (n = 565): stented segment length ≤20 mm; 2) group II (n = 278): stented segment length >20 but ≤35 mm; and 3) group III (n = 247): stented segment length >35 mm. RESULTS: There was no significant difference in the incidence of subacute stent thrombosis among the three groups (0.4% in group I, 0.4% in group II, 1.2% in group III; p = NS). The minimal lumen diameter (MLD) after stenting was greater in group I than in group III (3.04 ± 0.60 mm in group I, 3.01 ± 0.54 mm in group II, 2.91 ± 0.58 mm in group III; p < 0.05). At follow up, a smaller MLD was observed in group III as compared with group I and group II (2.04 ± 0.93 mm in group I, 1.92 ± 1.00 mm in group II, 1.47 ± 0.97 mm in group III; p < 0.01). The restenosis rates were 23.9% in group I, 34.6% in group II and 47.2% in group III (p < 0.01). Using multivariate analysis, the longer stented segment, the angiographic reference vessel diameter and the percent diameter stenosis after stenting were independent predictors of restenosis. CONCLUSIONS: The present study shows that a longer stented segment is an independent predictor of restenosis without an influence on the risk of subacute thrombosis.

Summary

Am J Cardiol 1999 Sep 1;84(5):515-8

Frequency and prognostic value of cardiac troponin I elevation after coronary stenting.

Mild myocardial injuries after coronary angioplasty are associated with adverse late outcomes. The incidence and prognostic value of this phenomenon when using cardiac troponin I (cTnI) after stent implantation is unknown. We studied cTnI and creatine kinase (CK) release in 109 patients after stenting. Clinical success was achieved in 103 patients (94%). In-hospital major adverse coronary events were: death in 1 patient, Q-wave myocardial infarction in 1 patient, and non-Q-wave myocardial infarction in 2 patients. Twenty-nine patients (27%) had postprocedural cTnI increase, 16 (15%) had CK elevation. No preprocedural variables predicted
marker elevation. Marker release was related to the occurrence of in-lab complications (59% vs 29% [p = 0.004 for cTnI] and 69% vs 32% [p = 0.011 for CK]) in 34% no explanation was found for cTnI increase. Success was more frequent in patients without cTnI elevation (100% vs 86%, p < 0.001). The negative predictive value of cTnI increase was 100% for in-hospital major adverse coronary events (MACE), whereas its positive predictive value was 14%. cTnI and CK concordant elevation was associated with more intra- and postprocedural adverse events. During a mean follow-up of 8+/–3 months, major adverse coronary events were: death in 2 patients, myocardial infarction in 2 patients, and repeat PTCA in 8 patients. cTnI elevation was not predictive of these late MACE. cTnI elevation is common after stenting, and is related to the occurrence of in-lab complications. Its isolated elevation is not a good predictor of MACE. Patients with concordant cTnI and CK elevation seem to be at higher risk of in-hospital MACE.

Summary
1. cTnI increase: 27%, CK elevation: 15%
2. No preprocedural variables predicted marker elevation.
3. Relation with in-lab complications: cTnI - 59% vs 29%(p = 0.004), CK - 69% vs 32%(p = 0.011)
4. Success was more frequent in patients without cTnI elevation (100% vs 86%, p < 0.001).
5. cTnI increase: 100% negative predictive value of cTnI for in-hospital MACE, 14% positive predictive value, no predictive value for late MACE

Am Heart J 1999 Sep;138(3 Pt 1):441-5

Long-term outcome of patients with very long stents for treatment of diffuse coronary disease.


OBJECTIVES: The study sought to determine the 6-month clinical outcome of patients who underwent implantation of very long coronary stents to treat diffuse disease and or long dissections and to compare the findings with those reported in the literature for patients who underwent implantation of multiple short coronary stents. BACKGROUND: New designs of flexible stents enable the implantation of long stents rather than multiple short, older design stents. The initial experience is very promising but the long-term outcome has not been described yet. METHODS: Fifty-seven consecutive patients in whom 67 long stents (>/>30 mm) were
successfully deployed were included in this study. Six-month clinical and angiographic follow-up was prospectively collected. Patients with recurrent angina underwent coronary angiography without further testing. Patients who remained asymptomatic at the 6-month follow-up visit underwent positron emission tomographic imaging, and those with results suggestive of ischemia underwent coronary angiography. A combined study end point was defined as death, myocardial infarction, and the need for target vessel revascularization. RESULTS: Only 1 patient (2%) reached a study end point at hospital discharge. An additional 20 patients (total 21 patients [37%]) reached an end point by 6 months. The outcome was not influenced by the clinical presentation (stable or unstable angina) or by the indication for stenting (elective or emergency). Predictors for adverse outcome were multiple stents per narrowing (63% vs 29%, P < .04), and stents smaller than 3.5 mm (49% vs 22%). Narrowing and stent length were not predictive of a study end point in narrowings that were successfully treated by a single long stent. CONCLUSIONS: Elective stenting provides an effective solution for patients with diffuse coronary disease provided that a single long stent (usually <40 mm) can cover the full length of the narrowing. The results are better when vessels larger than 3 mm are treated. Compared with multiple short stents, implantation of a single long stent is probably at least as effective, and the procedure is quicker and cheaper and thus should be the preferred approach.

Summary
1. Six month end point: 37%
2. Predictors for adverse outcome: multiple stents per narrowing (63% vs 29%, P < .04), and stents smaller than 3.5 mm (49% vs 22%).

Am J Cardiol 1999 Jun 15;83(12):1617-22

Influence of lesion length on restenosis after coronary stent placement.

Kastrati A, Elezi S, Dirschinger J, Hadamitzky M, Neumann FJ, Schomig A

The length of a coronary lesion is a significant predictor of restenosis after balloon angioplasty. The influence of lesion length has not comprehensively been assessed after coronary stent placement. This study includes 2,736 consecutive patients with coronary stent placement. Only patients with recent or chronic occlusions before the intervention were excluded. Patients were divided in 2 groups: 573 patients with long lesions (> or = 15 mm) and 2,163 patients with short lesions (< 15 mm). There were no significant differences between the groups with
respect to the procedural success rate and incidence of subacute thrombosis. One-year event-free survival was lower in patients with long lesions (73.3% vs 80.0%, p = 0.001). Six-month angiography was performed in 82.5% of the eligible patients. The incidence of binary restenosis (≥50% diameter stenosis) was higher in patients with long lesions (36.9% vs 27.9%, p < 0.001). Similarly, patients with long lesions presented more late lumen loss than those with short lesions (1.29 +/- 0.89 vs 1.07 +/- 0.77 mm, p < 0.001). Multivariate models for both binary restenosis and late lumen loss demonstrated that lesion length was an independent risk factor for restenosis. The risk was further increased by multiple stent placement and overlapping stents that were also independent risk factors of restenosis. Stented segment length did not show any independent effect. Therefore, long lesions represent an independent risk factor for restenosis after coronary stent placement. The results of this study suggest that a possible way to reduce the risk is to cover the lesion with a minimal number of nonoverlapping stents.

Summary

Am J Cardiol 1999 Apr 15;83(8):1170-4

Tissue proliferation within and surrounding Palmaz-Schatz stents is dependent on the aggressiveness of stent implantation technique.

Hoffmann R, Mintz GS, Mehran R, Kent KM, Pichard AD, Satler LF, Leon MB

In-stent restenosis is entirely due to intimal hyperplasia. Histologic studies have indicated that intimal hyperplasia is related to the arterial injury induced during stent implantation. We used intravascular ultrasound (IVUS) imaging to study whether tissue proliferation inside and surrounding stents is related to the aggressiveness of the implantation technique. After intervention and follow-up (mean 5.6 +/- 3.7 months), serial IVUS imaging was performed in 102 native artery stented stenoses in 91 patients. Measurements at 5 predetermined segments within each stented lesion included external elastic membrane, stent, and lumen cross-sectional areas (CSAs). Calculations included mean plaque CSA growth outside of the stent (external elastic membrane-stent) and mean neointimal hyperplasia CSA and thickness within the stent (stent-lumen). Stenoses were categorized depending on the aggressiveness of stent placement (group 1, adjunct percutaneous transluminal coronary angioplasty pressure < 16 atm and balloon/artery ratio < 1.1; group 2, adjunct percutaneous transluminal coronary angioplasty pressure ≥16 atm and balloon/artery ratio ≥1.1). An
aggressiveness score was calculated as balloon/artery ratio x inflation pressure. Mean intimal hyperplasia CSA (2.9 +/- 1.5 vs 2.2 +/- 1.6 mm², p = 0.028), mean intimal hyperplasia thickness (0.34 +/- 0.19 vs 0.25 +/- 0.19 mm, p = 0.012), and mean peristent tissue growth CSA (2.5 +/- 1.0 vs 1.1 +/- 1.4 mm², p = 0.003) were significantly greater in group 2 stenoses. In addition, intimal hyperplasia CSA and thickness correlated significantly with balloon/artery ratio x inflation pressures: r = 0.305, p = 0.002 and r = 0.329, p = 0.0007, respectively, as did peristent tissue proliferation CSA (r = 0.466, p = 0.001). Tissue proliferation inside and surrounding stents may be related to aggressiveness of the stent implantation technique.

Summary
IH: intimal hyperplasia, TP: tissue proliferation

Am Heart J 1999 Feb;137(2):292-7

Long-term follow-up study of coronary reconstruction with multiple stents.

Liu MW, Luo JF, Dean LS, Baxley WA, Iyer SS, Sutor RJ, Negus B, Roubin GS

BACKGROUND: Conventional balloon angioplasty of very long de novo coronary lesions or very long coronary dissection caused by angioplasty is associated with low success and high complication rates. Multiple intracoronary stents have been used to treat both conditions, although long-term efficacy has not been defined. METHODS AND RESULTS: Between June 1993 and December 1995, 47 consecutive patients underwent native coronary angioplasty and stenting with 4 or more stents covering at least 2 consecutive diseased coronary segments. Preangioplasty and poststenting diameter stenoses were 81% +/- 13% and 21% +/- 12%, respectively. Reference vessel diameters were 3.53 +/- 0.55 mm proximal to the stents and 2.95 +/- 0.62 mm distal to the stents. Average lesion length was 63 +/- 20 mm. The number of stents used was 4.5 +/- 1 per vessel (from 4 to 7). Gianturco Roubin I stents were used in all patients. Coronary Palmaz-Schatz stents were used as supplementary stents in 3 patients. Angiographic success was 100%. In-hospital outcomes include 1 death, 1 coronary bypass surgery, no Q-wave myocardial infarction, and 7 non-Q-wave myocardial infarctions. Long-term follow-up at 430 +/- 199 days was completed in all patients. Thirty-five (76%) patients were asymptomatic, 8 (17%) had class 1 or 2 angina, 1 had a myocardial infarction, 13 (28%) underwent repeat angioplasty, 2 patients had subsequent elective bypass surgery, and 3 died during follow-up. CONCLUSIONS: Multiple intracoronary stents for very long lesions or dissection can be performed with acceptable immediate and long-
term outcomes.

Summary
1. Angiographic success: 100%.
2. In-hospital outcomes: 1 death, 1 coronary bypass surgery, and 7 non-Q MI.
3. Long-term follow-up: asymptomatic - 76%, class 1 or 2 angina - 17%, 1 myocardial infarction, 13 (28%) repeat angioplasty, 2 subsequent elective bypass surgery, and 3 death.

Effects of Probucol on Vascular Remodeling After Coronary Angioplasty

Gilles Cote, Jean-Claude Tardif, Jacques Lesperance, Jean Lambert, Martial Bourassa, Raoul Bonan, Gilbert Gosselin, Michel Joyal, Jean-Francois Tanguay, Stanley Nattel, Richard Gallo, and Jacques Crepeau

Background-We have shown that probucol reduces restenosis after balloon angioplasty. Whether probucol acted via prevention of neointimal formation or improvement in vascular remodeling could not be addressed by angiography and required the use of intravascular ultrasound (IVUS).

Methods and Results-Beginning 30 days before angioplasty, 317 patients were randomly assigned to receive probucol, multivitamins, combined treatment, or placebo. Patients were then treated for 6 months after angioplasty. IVUS examination was performed immediately after angioplasty and at follow-up in 94 patients (111 segments). The cross section selected for serial analysis was the one at the angioplasty site with the smallest lumen area at follow-up. In the placebo group, lumen area decreased by -1.21±1.88 mm² at follow-up, and wall area and external elastic membrane (EEM) area increased by 1.50±2.50 and 0.29±2.93 mm², respectively. Change in lumen area, however, correlated more strongly with the change in EEM area (r=0.53, P=0.002) than with the change in wall area (r=0.13, P=0.49). Lumen loss was -1.21±1.88 mm² for placebo, -0.83±1.22 mm² for vitamins, -0.25±1.17 mm² for combined treatment, and -0.15±1.70 mm² for probucol alone (P=0.002 for probucol, P=0.84 for vitamins). Change in wall area was similar for all groups. EEM area increased by 0.29±2.93 mm² for placebo, 0.09±2.33 mm² for vitamins only, 1.17±1.61 mm² for combined treatment, and 1.74±1.80 mm² for probucol only (P=0.005 for probucol).

Conclusions-Lumen loss after balloon angioplasty is due to inadequate vessel remodeling in response to neointimal formation. Probucol exerts its antirestenotic effects by improving vascular remodeling after...
angioplasty.

Am Heart J 2000;139:437-45

Stents covered by autologous venous grafts: Feasibility and immediate and long-term results

Christodoulos Stefanadis, MD, FACC, FESC, Konstantinos Toutouzas, MD, Eleftherios Tsiamis, MD, Charalambos Vlachopoulos, MD, Ioannis Kallikazaros, MD, Costas Stratos, MD, Manolis Vavuranakis, MD, FACC, Pavlos Toutouzas, MD, FACC, FESC
Athens, Greece

Background Previous experimental studies with a new covered stent, the autologous venous graft-covered stent (AVGCS), have shown favorable results. The aim of this study was to evaluate the feasibility and safety of this new technique in human coronary arteries and to compare the long-term outcome with uncovered stents.

Methods and Results A venous graft was removed from an upper limb. A conventional stent then was covered by the venous graft. Fifty-eight AVGCS were implanted in 56 patients, including 16 patients with acute coronary syndromes (ACS). Additionally, in 114 patients, 138 uncovered stents were implanted, serving as a control group, including 38 patients with ACS. The procedure was successful in all patients. Stent thrombosis was observed in 3 patients in the control group and in 1 patient with an AVGCS. There was a trend for the minimal luminal diameter to be greater in the AVGCS group at follow-up (P = .07), and statistical significance was observed in patients with ACS (P < .01). The target vessel revascularization and the restenosis rates were similar between the 2 groups. In patients with ACS, the restenosis rate was less (P < .04) and there was a trend for target vessel revascularization to be less in covered stents (P = .09). The event-free survival rate at 4 years was 85% in the AVGCS group versus 81% in the control group (P = not significant); in ACS it was 94% versus 78%, respectively (P = not significant). Stents covered by thicker venous grafts were associated with improved clinical outcome.

Conclusions Stents covered by autologous venous grafts may be safely prepared without complications. This technique may prove to be a useful means, especially in patients with ACS.

Circulation 2000 ;102: 2024-2027
Background-Stent implantation in lesions of degenerated aortocoronary vein grafts is associated with a high risk of periprocedural thrombus embolization and in-stent restenosis.

Methods and Results-In a multicenter study, we followed up 109 consecutive patients (mean age 66±8 years, 12% female) who received polytetrafluoroethylene (PTFE) membrane-covered stents for 125 de novo stenoses in vein grafts 11±5 years after bypass surgery. Stent deployment was successful in all but 1 patient; 1 patient suffered from subacute stent thrombosis. Six-month cardiac mortality was 7% (8 patients), 3 patients (3%) underwent repeat bypass surgery, and 9 patients (8%) required target-lesion PTCA. Repeat angiography revealed vessel occlusions in 9% and in-stent restenosis in 8% of patients by the end of follow-up.

Conclusions-Membrane-covered stents appear to be a safe and efficient treatment strategy associated with a low incidence of restenosis and target-vessel revascularization. Compared with previous studies, the investigated device is not associated with an increase in mortality or late vessel occlusions.
developed non-Q myocardial infarction and one patient underwent emergency bypass surgery due to a large dissection after stenting. Angiographic restenosis rate was 26.1% (18,69), and target lesion revascularization rate 11.7%. The final luminal diameter after stenting was the only predictor of angiographic restenosis. Clinical follow-up was obtained in all patients at 21.5 ± 16.0 months. Two patients died during the follow-up. Event-free survival rate was 84.6 ± 3.8%. In conclusions, stenting with or without debulking atherectomy may be considered as an acceptable therapeutic option for the treatment of ostial LAD stenosis.

Journal of the American College of Cardiology, 35:3:612-618

Procedural results and late clinical outcomes after percutaneous interventions using long (≥25 mm) versus short (<20 mm) stents

Ran Kornowski, Balram Bhargava, D.M. Shmuel Fuchs, Alexandra J. Lansky, Lowell F. Satler, Augusto D. Pichard, Mun K. Hong, Kenneth M. Kent, Roxana Mehran, Gregg W. Stone, Martin B. Leon

OBJECTIVES To evaluate clinical outcomes after the use of long coronary stents.
BACKGROUND
The use of long slotted-tube stents has been recently approved in the U.S. to treat long lesions or dissections. Procedural success and long-term outcomes of long versus short stents have not been established.
METHODS
We evaluated procedural success, major in-hospital complications, target lesion revascularization and long-term (one year) clinical outcomes in 1,226 consecutive patients (1,259 native coronary lesions) who underwent a single vessel intervention using a single long (≥25 mm, 116 patients) or short (<20 mm, 1,110 patients) tubular-slotted stent.
RESULTS
Patients treated with long stents had more diffuse (>10 mm length) lesions (63% vs. 28%, p = 0.001). The mean stent length was 28 ± 5 mm versus 15 ± 2 mm for long versus short stent groups (p = 0.001). Overall procedural success was similar in the long versus short stent groups (96% vs. 98%, p = 0.08). However, major in-hospital complications tended to occur more frequently in patients treated with longer stents (3.4% vs. 1.0%, p = 0.04). The rate of periprocedural non-Q-wave myocardial infarction (MI) (creatine kinase-MB≥5 times normal) was notably higher after long stent implantation (23% vs. 11%, p = 0.001). Target lesion revascularization at one year was 14.5% vs. 13.8% (p = 0.69), and target vessel revascularization rate was 19.6%
vs. 17.3% (p = 0.41) in the long versus short stent group, respectively. There was no difference in one year mortality (2.5% vs. 3.5%, p = 0.49) or Q-wave MI (2.7% vs. 1.2%, p = 0.48), and the overall cardiac event-free survival was similar for the two groups (81%).

CONCLUSIONS

The use of single coronary long (≥25 mm) versus short (<20 mm) stents is associated with: 1) somewhat increased major procedural complications, 2) significantly higher frequency of periprocedural non-Q-wave MIs, and 3) equivalent repeat revascularization risk and cardiac event-free survival out-of-hospital up to one year.

Journal of the American College of Cardiology, 2000;35:6:1554-1559

Influence of treatment modality on angiographic outcome after coronary stenting in diabetic patients: a controlled study

Joachim Schofer, Michael Schluter, Thomas Rau, Falk Hammer, Natalie Haag, Detlef G. Mathey

OBJECTIVES This retrospective study was designed to determine the six-month angiographic outcome after stenting of native coronary arteries in insulin-treated (ITDM) and non-ITDM patients with diabetes mellitus (DM) and compare the results with those in non-DM patients.

BACKGROUND

The influence of the treatment modality for DM on restenosis in patients undergoing coronary artery stenting has not been elucidated sufficiently.

METHODS

A total of 1,439 (70%) of 2,061 patients underwent repeated angiography within six months of coronary stenting. The ITDM and non-ITDM (oral hypoglycemic drugs or diet) were documented in 48 (3.3%) and 177 patients (12.3%), respectively, leaving 1,214 non-DM patients.

RESULTS

Baseline reference vessel diameter tended to be smaller in ITDM patients (mean, 2.73 mm) than in non-DM and non-ITDM patients (2.88 mm and 2.85 mm, respectively). However, percent diameter stenosis was not different. The median number of stents deployed was 1; median stent length was 15 mm. Statistically significant differences were present after stenting for the means of minimal lumen diameter (MLD) and acute gain between ITDM patients (MLD: 2.67 mm, acute gain: 1.98 mm) and non-DM patients (MLD: 2.81 mm, acute gain: 2.16 mm). At follow-up, percent diameter stenosis, late lumen loss and loss index were significantly
higher in both non-ITDM lesions (42%, 1.14 mm and 0.56, respectively) and ITDM lesions (48%, 1.26 mm and 0.65, respectively) than in non-DM lesions (35%, 0.96 mm and 0.45, respectively). The corresponding differences between non-ITDM and ITDM lesions did not reach statistical significance. Restenosis rates in non-DM, non-ITDM and ITDM lesions were 23.8%, 32.8% (p = 0.013 vs. non-DM) and 39.6% (p = 0.02 vs. non-DM, p = 0.477 vs. non-ITDM), respectively.

CONCLUSIONS
This study showed that compared with stenting in non-DM patients, stenting of native coronary arteries in DM patients is associated with significantly increased lumen renarrowing, regardless of the treatment modality for DM.

Journal of the American College of Cardiology, 2000;35:4:937-943

Immediate and late outcomes after direct stent implantation without balloon predilation


OBJECTIVES
The aim of our study was to compare the in-hospital and long-term clinical outcomes of direct coronary stenting with balloon predilation followed by stent placement.

BACKGROUND
With improvement in stent designs, the practice of direct stenting without balloon predilation has become more widespread.

METHODS
We analyzed the Mayo Clinic Coronary Intervention data base between January 1, 1995 and March 5, 1999 and identified 777 patients who were treated with direct stenting (DS) and 3,176 patients treated with balloon angioplasty plus stenting (BA+S).

RESULTS
The procedural success rates between the DS and BA+S groups were not significantly different (96.3% vs. 96.4%). The ability to deliver the stent in a subgroup of patients who had DS was 95%, with 5% requiring crossover to predilation. Multivariate analysis showed no significant differences with respect to in-hospital death (odds ratio [OR] 0.9, 95% confidence interval [CI] 0.5 to 1.8), in-hospital myocardial infarction (OR 0.9,
95% CI 0.6 to 1.2) or revascularization (OR 0.7, 95% CI 0.4 to 1.5) in the DS compared with the BA+S group. Long-term outcomes were not significantly different between the DS and BA+S groups. The procedural duration was significantly shorter in the DS group, and there was a decreased utilization of contrast agent, balloons and wires.

CONCLUSIONS
The in-hospital and long-term clinical outcomes in patients undergoing a coronary intervention are equivalent when comparing stenting without balloon predilation with balloon angioplasty followed by stenting. Direct stenting is associated with decreased utilization of contrast agent and equipment and shorter procedure times. A randomized study should be performed to better determine the impact of this technique on short- and long-term procedural outcomes.

The American Journal of Cardiology, 85:9:1065-1070

Long-term outcome in patients treated by intracoronary stenting with ticlopidine and aspirin, and deleterious prognostic role of unstable angina pectoris

Michael Angioi, Nicolas Danchin, Francois Alla, Catherine Gangloff, Henri Sunthorn, Rosa-Maria Rodriguez, Jean-Philippe Preiss, Alain Grentzinger, Philippe Houplon, Yves Juilliere, Francois Cherrier

Compared with stable clinical conditions, unstable angina carries an increased risk of immediate and delayed cardiac adverse events after balloon coronary angioplasty. The influence of stent use in reducing these differences remains unknown. We analyzed the early (30 days) and late outcome of a cohort of 459 consecutive patients who underwent stent placement with ticlopidine and aspirin as antithrombotic regimen according to the presence (group 1, n = 151) or absence (group 2, n = 308) of unstable angina at rest (Braunwald classes II and III). Group 1 patients were older and more likely to be current or former smokers. In group 2, prior myocardial infarction was more frequent. Procedural, in-hospital results, and early outcome were similar in the 2 groups. However, over the long term, the incidence of myocardial infarction (11% vs 6%, p <0.04), target lesion revascularization (19% vs 13%, p <0.04), or any revascularization (30% vs 20%, p <0.01) was significantly higher in group 1. Kaplan-Meier probabilities of survival without myocardial infarction (85% vs 91%, p <0.05), survival without revascularization of the target lesion (73% vs 83%, p <0.01), survival without any revascularization (65% vs 77%, p <0.006), and survival without any events (61% vs 73%, p <0.009) were significantly worse in group 1. In addition, Cox multivariate analysis showed that unstable angina at rest was an independent
predictor of target lesion revascularization, of survival without any revascularization, and without any events. Thus, unstable angina at rest remains an adverse prognostic indicator in patients treated with intracoronary stents, particularly with regard to subsequent requirement of revascularization procedures and event-free survival.


Randomized Comparison of GR-II Stent and Palmaz-Schatz Stent for Elective Treatment of Coronary Stenoses


Background-This prospective multicenter randomized clinical trial was designed to evaluate the long-term angiographic and clinical outcomes of elective treatment with the GR-II stent compared with the Palmaz-Schatz (PS) stent in patients with coronary stenoses.

Methods and Results-Seven hundred fifty-five patients with myocardial ischemia and de novo native coronary stenoses in 3- to 4-mm vessels were randomly assigned to the PS (375 patients) or the GR-II stent (380 patients). The primary end point was 12-month target lesion revascularization (TLR)-free survival. Angiography was performed at baseline and at follow-up in the first 300 consecutive patients to assess the frequency of angiographic restenosis. Procedure success was 98.5% for the GR-II stent and 99.4% for the PS stent (P=0.19). At 30 days, patients assigned to the GR-II stent had a higher stent thrombosis rate (3.9% versus 0.3% for PS stent, P<0.001) and TLR rate (3.9% versus 0.5% for PS stent, P<0.001). The GR-II group had a higher follow-up restenosis frequency (47.3% versus 20.6% for the PS group, P<0.001) and a lower 12-month TLR-free survival rate (71.7% versus 83.9% for the PS group, P<0.001). Multivariate logistic regression analysis identified a smaller final stent minimal lumen diameter (odds ratio [OR] 2.49, 95% CI 1.56 to 3.98; P<0.001), diabetes mellitus (OR 2.14, 95% CI 1.42 to 3.22; P<0.001), and use of the GR-II stent (OR 1.78, 95% CI 1.20 to 2.64; P<0.01) as independent determinants of 12-month TLR.

Conclusions-On the basis of these long-term follow-up data, we conclude that use of the GR-II stent should be limited to the acute treatment of abrupt or threatened closure after failed conventional balloon angioplasty procedures.
Nine-year follow-up of balloon-expandable Palmaz-Schatz stent in patients with single-vessel disease

Carma Karam, Jean Fajadet, Alain Beauchet, Bernard Cassagneau, Jean Marco

Abstract
The long-term effects of intracoronary stents in human are unknown. This is the first 9-year follow-up report of single-vessel-disease patients treated with the Palmaz-Schatz stent. Between March and December 1989, out of the 107 patients undergoing Palmaz-Schatz stent implantation, 71 (66%) had single-vessel disease. The average age of these patients was 58 ± 9 years and 79% were men. At 9 years, follow-up was obtained for 90.1% and major adverse clinical events consisted of 4 deaths giving a global survival rate of 95.8%, 7 myocardial infarction, 3 bypass surgeries, and 16 repeat percutaneous revascularization procedures. The 9-year event-free survival rate was 60%, and 81.7% of the patients were free from death, myocardial infarction, and bypass surgery. Multivariate analysis showed that the only predictive factor of major adverse clinical events was the presence of diabetes mellitus (P < 0.004).

Long-term clinical events following creatine kinase-myocardial band isoenzyme elevation after successful coronary stenting

Jorge F. Saucedo, Roxana Mehran, George Dangas, Mun K. Hong, Alexandra Lansky, Kenneth M. Kent, Lowell F. Satler, Augusto D. Pichard, Gregg W. Stone, Martin B. Leon

OBJECTIVE
We sought to evaluate the impact of intermediate creatine kinase-myocardial band isoenzyme (CK-MB) elevation on late clinical outcomes in patients undergoing successful stent implantation in native coronary...
arteries.

BACKGROUND

Elevations of CK-MB after percutaneous coronary interventions are frequent. An association between high level of CK-MB elevation (>5 times normal) and late mortality after balloon and new device angioplasty has been reported previously. However, significant controversy remains on the long-term clinical importance of lower CK-MB elevations (one to five times normal) after percutaneous coronary revascularization. Moreover, the incidence and prognostic importance of cardiac enzyme elevation after coronary stenting have not been well established.

METHODS

Prospectively collected data from 900 consecutive patients (1,213 lesions) undergoing successful stenting in native vessels were analyzed. Based on the CK-MB levels after coronary stenting, patients were classified into three groups: normal group 1 (n = 585), elevation of >1 to 5 times normal group 2 (n = 238) and elevation of >5 times normal group 3 (n = 77).

RESULTS

Patients in group 3 had more in-hospital recurrent ischemia (p = 0.001) and pulmonary edema (p = 0.01) than patients in groups 1 and 2. Long-term clinical end points were similar between groups 1 and 2. However, patients in group 3 had an increased incidence of late mortality compared with patients in groups 2 and 1 (6.9%, 1.2% and 1.7%, respectively, p = 0.01). Multivariate analysis showed that patients with CK-MB >5 times normal after coronary stenting had an increased risk of major adverse clinical events (relative risk: 1.70, p < 0.05) and death (relative risk: 3.25, p < 0.05) that was not observed in patients with lower CK-MB rise.

CONCLUSIONS

Patients with CK-MB elevation >5 times normal had higher late mortality and more unfavorable event-free survival than those patients with normal or lower CK-MB rise after coronary stenting. While intermediate CK-MB elevation (>1 to 5 times normal) is frequent after coronary stenting (26%), this was not associated with an increased risk of late mortality or major adverse clinical events.

The American Journal of Cardiology, 85:8:957-961

Balloon optimization versus stent study (BOSS): provisional stenting and early recoil after balloon angioplasty

George Dangas, John A. Ambrose, Diane Rehmann, Jonathan D. Marmur, Samin K. Sharma, Craig Hemdal-Monsen, Timothy A. Sanborn, David L. Fischman
Optimal percutaneous transluminal coronary angioplasty (PTCA) may have a late restenosis rate similar to stenting. We sought to assess short- and long-term results of a provisional stenting/optimal PTCA approach compared with elective stenting in a prospective, randomized study. A total of 97 patients with discrete, de novo lesions in native coronary arteries ≥3 mm in diameter were randomized 2:1 in PTCA with prolonged perfusion balloon inflation (n = 66) versus elective stenting (n = 31). Recoil after PTCA was assessed by routine delayed angiograms (5 and 20 minutes). Cross over to stent was allowed for an inadequate result; there was no on-line quantitative angiography. An independent core angiographic laboratory assessed all results and evaluated the adequacy of the subjective interpretation. Within the PTCA arm, there were 24 (36%) crossovers to stenting (5 of 24 [21%] due to recoil), whereas 2 stents could not be delivered to the lesion and crossed over to PTCA. As assessed by quantitative angiography, baseline reference vessel diameters were similar between the PTCA and stent groups. The immediate lumen diameter achieved with PTCA was smaller than that achieved with stenting (2.18 ± 0.49 vs 2.44 ± 0.38 mm, respectively, p = 0.01). There were no differences in angiographic results between elective and crossover stenting and there were no in-hospital complications in any patient. Target lesion revascularization at 8 months was 19% (n = 6) in the elective stent arm versus 21% (n = 14) in the PTCA arm, p = NS; respective rates in PTCA alone and crossed over-to-stent subsets were 23% (n = 10) versus 17% (n = 4), p = NS. Angiographic restenosis was 47% after elective stenting versus 38% after PTCA (intention to treat), p = NS. By received treatment, it was 41% (11 of 27) in the group treated with the PTCA versus 33% (5 of 15) in the crossover-to-stent arm (p = NS). Thus, provisional stenting can be safely performed in the treatment of discrete, native de novo lesions. Early recoil after PTCA cannot be reliably assessed without quantitative angiography.

Journal of the American College of Cardiology, 2000;35:6:1560-1568

Comparison of debulking followed by stenting versus stenting alone for saphenous vein graft aortoostial lesions: immediate and one-year clinical outcomes


OBJECTIVES We compared in-hospital and one-year clinical outcomes in patients undergoing debulking followed by stent implantation versus stenting alone for saphenous vein graft (SVG) aortoostial lesions.

BACKGROUND
Stent implantation in SVG aortoostial lesions may improve procedural and late clinical outcomes. However, the impact of debulking before stenting in this complex lesion subset is unknown.

METHODS
We studied 320 consecutive patients (340 SVG aortoostial lesions) treated with Palmaz-Schatz stents. Debulking with excimer laser or atherectomy was performed in 133 patients (139 lesions) before stenting (group I), while 187 patients (201 lesions) underwent stent implantation without debulking (group II). Procedural success and late clinical outcomes were compared between the groups.

RESULTS
Overall procedural success (97.6%) was similar between the groups. Procedural complications were also similar (2.2% for group I and 2.6% for group II). At one-year follow-up, target lesion revascularization (TLR) was 19.4% for group I and 18.2% for group II (p = 0.47). There was no difference in cumulative death or Q wave myocardial infarction between the groups. Overall cardiac event-free survival was similar (69% for group I and 68% for group II). By Cox regression analysis, the independent predictors of late cardiac events were final lumen cross-sectional area (CSA) by intravascular ultrasound (IVUS) (p = 0.001) and restenotic lesions (p = 0.01). Similarly, final IVUS lumen CSA (p = 0.0001) and restenotic lesions (p = 0.006) were found to predict TLR at one year.

CONCLUSIONS
These results suggest that, in most patients with SVG aortoostial lesions, debulking before stent implantation may not be necessary.

The American Journal of Cardiology, 2000;85:8:962-968

Effect of statin therapy on restenosis after coronary stent implantation

Dirk H. Walter, Volker Schachinger, Mathias Elsner, Stefan Mach, Wolfgang Auch-Schwelk, Andreas M. Zeiher

The effect of statins on the development of restenosis and clinical outcome after coronary stent implantation was assessed in a retrospective analysis of 525 consecutive patients. Baseline clinical, angiographic, and procedural characteristics did not differ between 258 patients with and 267 patients without statin therapy. Statin therapy was associated with a significantly (p <0.04) improved survival free of myocardial infarction and a significant reduction in repeat target vessel revascularization procedures (27.9% vs 36.7%, p <0.05) during 6-month follow-up. Minimal lumen diameter was significantly larger (1.98 ± 0.88 vs 1.78 ± 0.88 mm, p = 0.01),
late lumen loss was significantly less (0.64 ± 0.8 vs 0.8 ± 0.8 mm, p = 0.032), and net gain significantly increased (1.2 ± 0.88 vs 0.98 ± 0.92 mm, p = 0.009) in patients receiving statin therapy. Dichotomous angiographic restenosis (≥50%) rates were significantly lower, with 25.4% in the statin group compared with 38% in the no-statin group (p <0.005). Multivariate analysis identified statin therapy (p = 0.005), minimal lumen diameter immediately after stenting (p = 0.02), and stent length (p = 0.02) as independent predictors for subsequent restenosis development. Thus, statin therapy is associated with reduced recurrence rates and improved clinical outcome after coronary stent implantation.

Journal of the American College of Cardiology, 2000;36:5:1549-1556

Fate of stent-related side branches after coronary intervention in patients with in-stent restenosis

Fernando Alfonso, Carlos Hernandez, Maria Jose Perez-Vizcayno, Rosana Hernandez, Antonio Fernandez-Ortiz, Javier Escaned, Camino Banuelos, Manel Sabate, Marcelo Sanmartin, Cristina Fernandez, Carlos Macaya

OBJECTIVES We sought to assess the fate of stent (ST)-related side branches (SB) after coronary intervention in patients with in-ST restenosis.

BACKGROUND
In-ST restenosis constitutes a therapeutic challenge. Although the fate of lesion-related SB after conventional angioplasty or initial coronary stenting is well established, the outcome of ST-related SB in patients with in-ST restenosis undergoing repeat intervention is unknown.

METHODS
One hundred consecutive patients (age 61 ± 11 years, 22 women) undergoing repeat intervention for in-ST restenosis (101 ST) were prospectively studied. Two hundred and twenty-six SB spanned by the ST were identified. The SB size, type, ostium involvement, location within the ST and take-off angle were evaluated. The SB TIMI (Thrombolysis in Myocardial Infarction trial) flow grade was studied in detail before, during, immediately after the procedure, and at late angiography.

RESULTS
Oclusion (TIMI flow GRADE = 0) was produced in 24 (10%) SB, whereas some degree of flow deterioration (1 TIMI flow grade) was observed in 57 SB (25%). The SB occlusion was associated with non-Q wave myocardial infarction in two patients (both had large and diseased SB). Side-branch occlusion at the time of initial stenting (RR [relative risk] 11.1, 95% CI [confidence interval] 3.5-35.5, p < 0.001), diabetes (RR 3.5, 95% CI 1.1-10.5, P =
SB ostium involvement (RR 5.0, 95% CI 1.4-17.2, P = 0.004), baseline SB TIMI flow grade <3 (RR 5.5, 95% CI 1.7-18.1, P = 0.005), and restenosis length (RR 1.05 95% CI 1.01-1.11, P = 0.03) were identified as independent predictors of SB occlusion. Late angiography in 19 initially occluded SB revealed that 17 (89%) were patent again. The long-term clinical event-free survival (81% vs. 82% at two years) in patients with and without initial SB occlusion was similar.

CONCLUSIONS

Occlusion or flow deterioration of SB spanned by the ST is relatively common during repeat intervention for in-ST restenosis. Several factors (mainly anatomic features) are useful predictors of this event. However, most SB occlusions are clinically silent and frequently reappear at follow-up.


Assessment of Coronary Arterial Restenosis With Phase-Contrast Magnetic Resonance Imaging Measurements of Coronary Flow Reserve

W. Gregory Hundley, MD; L. David Hillis, MD; Craig A. Hamilton, PhD; Robert J. Applegate, MD; David M. Herrington, MD, MHS; Geoffrey D. Clarke, PhD; Gregory A. Braden, MD; Mark S. Thomas, RN; Richard A. Lange, MD; Ronald M. Peshock, MD; Kerry M. Link, MD

Background-After successful percutaneous coronary arterial revascularization, 25% to 60% of subjects have restenosis, a recurrent coronary arterial narrowing at the site of the intervention. At present, restenosis is usually detected invasively with contrast coronary angiography. This study was performed to determine if phase-contrast MRI (PC-MRI) could be used to detect restenosis noninvasively in patients with recurrent chest pain after percutaneous revascularization.

Methods and Results-Seventeen patients (15 men, 2 women, age 36 to 77 years) with recurrent chest pain >3 months after successful percutaneous intervention underwent PC-MRI measurements of coronary artery flow reserve followed by assessments of stenosis severity with computer-assisted quantitative coronary angiography. The intervention was performed in the left anterior descending coronary artery in 15 patients, one of its diagonal branches in 2 patients, and the right coronary artery in 1 patient. A PC-MRI coronary flow reserve value ≤2.0 was 100% and 82% sensitive and 89% and 100% specific for detecting a luminal diameter narrowing of ≥70% and ≥50%, respectively.

Conclusions-Assessments of coronary flow reserve with PC-MRI can be used to identify flow-limiting stenoses
(luminal diameter narrowings >70%) in patients with recurrent chest pain in the months after a successful percutaneous intervention.

J Am Coll Cardiol 2000 Feb;35(2):389-97

Procedural results and intermediate clinical outcomes after multiple saphenous vein graft stenting.


OBJECTIVES: We evaluated the early and mid-term (18-month) clinical events in a consecutive series of patients undergoing a nonstaged multiple saphenous vein grafting (SVG) intervention with stents as compared with a single SVG stent procedure. BACKGROUND: Saphenous vein graft angioplasty has been limited by high rates of distal embolization, myocardial infarction, restenosis and late mortality. It is unknown whether stenting of multiple, different SVGs at the same setting is associated with higher risk. METHODS: We evaluated in-hospital and mid-term clinical outcomes (death, Q wave myocardial infarction [MI] and repeat revascularization rates up to 18 months) in 70 consecutive patients treated with coronary stents in 2 (93% of patients) or 3 SVGs, as compared with 649 patients undergoing stenting of a single SVG between January 1, 1994 and December 31, 1997. RESULTS: Overall procedural success was obtained in 97% of patients with 2 or 3 SVGs and 97% of patients with a single SVG (p = 0.94). Procedural complications were also similar (2.8% for multiple SVGs vs. 2.7% for a single SVG, p = 0.94). There was a higher prevalence of periprocedural non-Q wave MI (28% vs. 16%, p = 0.009) in the multiple SVG group. During follow-up (18 months), target lesion revascularization was 11% in multiple SVG and 15% in single SVG interventions (p = 0.19), and repeat revascularization (calculated per treated patient) was also similar for both groups (19% vs. 18%, p = 0.94). There was no difference in death (5.6% vs. 5.3%, p = 0.92) and Q wave MI rate (4.3% vs. 2.9%, p = 0.55) after the multiple SVG intervention. Overall cardiac event-free survival was similar for both groups (62% vs. 60%, p = 0.75). The study was powered to detect a clinically meaningful difference of 10% in mortality; smaller differences could not be evaluated on the basis of this sample size. CONCLUSIONS: Simultaneous stenting of multiple SVGs in carefully selected patients has similar in-hospital procedural success and major complications rates, as well as mid-term (18-month) clinical outcomes, as compared with single SVG stenting. Thus, multiple SVG interventions using stents may be a viable revascularization strategy for carefully selected patients and suitable lesions in multiple SVG disease.
Angiographic patterns of in-stent restenosis and implications on subsequent revascularization.

Kini A, Marmur JD, Dangas G, Choudhary S, Sharma SK

Stent implantation has become the mainstay of percutaneous revascularization for most coronary lesions; in-stent restenosis (ISR) can occur in 6%-40% of stent procedures and the subsequent response to repeat intervention can possibly be predicted by the angiographic patterns of ISR. This study evaluated the incidence and predictors of angiographic patterns of ISR and its impact on subsequent target lesion revascularization (TLR) in 100 consecutive patients having Palmaz-Schatz ISR undergoing intervention. Diffuse ISR (≥10 mm) was observed in 78% and focal ISR (>10 mm) in 22%. Diffuse vs. focal ISR occurred earlier after stent implantation and was more common in diabetics. Angiographic predictors of diffuse ISR were stent implantation for a restenotic lesion, long lesions, smaller vessel, stenting without debulking, and high-pressure balloon inflation (>16 atm). TLR after repeat intervention was 46% for diffuse and 14% for focal ISR (P < 0.02). Rotational atherectomy resulted in lower TLR (31%) vs. PTCA or restent (64%) in diffuse ISR (P < 0.004). Therefore, diffuse ISR is more common than focal ISR, usually occurs in the setting of aggressive intimal hyperplasia, and can be predicted by clinical and angiographic variables. Also, diffuse intimal hyperplasia within a stent responds poorly to PTCA and may benefit from a more aggressive debulking strategy such as rotational atherectomy.

Summary
1. Diffuse ISR: 78%, focal ISR: 22%.
2. Diffuse ISR - occurred earlier, more common in diabetics.
3. Angiographic predictors of diffuse ISR: stent implantation for a restenotic lesion, long lesions, smaller vessel, stenting without debulking, and high-pressure balloon inflation (>16 atm).
4. Rotational atherectomy resulted in lower TLR (31%) vs. PTCA or restent (64%) in diffuse ISR (P < 0.004).

Previous cytomegalovirus infection and risk of coronary thrombotic events after stent placement.
BACKGROUND: Cytomegalovirus (CMV) infection induces upregulation of tissue factor and loss of anticoagulants, including thrombomodulin, prostacyclin, and tissue plasminogen activator. CMV infection may thereby increase the procoagulant properties of coronary artery plaques. This prospective study investigated the effect of previous CMV infection on the early hazard of coronary stent placement. METHODS AND RESULTS: In 551 consecutive patients with successful coronary stent placement, we determined CMV IgG titers. The end point was the composite rate of death, nonfatal Q-wave myocardial infarction, and urgent reintervention during 30-day follow-up. The study population represented the entire spectrum of coronary stenting; an acute coronary syndrome was present in 50% of the patients. A positive CMV IgG titer (\(\geq 1/230\)) was found in 340 patients (62%). Of these, 10 reached the end point during 30-day follow-up (2 deaths, 4 infarctions, 4 urgent reinterventions). In the group with negative CMV titer, thrombotic events did not occur (\(P=0.014\) versus group with positive CMV titers). After correction for pertinent covariables, a significant relation between positive CMV titer and the 30-day end point prevailed (\(P<0.001\)). CONCLUSIONS: Previous CMV infection may increase the risk of coronary thrombotic events after stent placement.

Summary
Type of end points (all occurred in CMV(+) patients)

Am J Cardiol 2000 Aug;86(4):385-9

Heparin-coated Wiktor stents in human coronary arteries (MENTOR trial)

Vrolix MC. Legrand VM. Reiber JH. Grollier G. Schalij MJ. Brunel P. Martinez-Elbal L. Gomez-Recio M. Bar FW. Bertrand ME. Colombo A. Brachman J.

The purpose of this study was to determine the feasibility, safety, and efficacy of elective stenting with heparin-coated Wiktor stents in patients with coronary artery disease. In experimental studies, heparin coating has been shown to prevent subacute thrombosis and restenosis. Recently, a new method of heparin coating was developed, resulting in a more stable and predictable heparin layer on stent devices. This trial constitutes the
first in-human use of this coating procedure, applied on the well-known Wiktor stent device. Heparin-coated Wiktor stent implantation was performed in 132 consecutive patients (132 lesions) in a multicenter international trial from September 1996 to February 1997. Forty-three percent of patients had unstable angina, 33% had previous myocardial infarction, and 10% had diabetes mellitus. Patients were followed for 12 months for occurrence of major adverse cardiovascular events, and 96% of the eligible patients underwent quantitative angiographic control at 6 months. Stent deployment was successful in 95.5% of lesions. Minimal lumen diameter increased by 1.67 +/- 0.48 mm (from 1.02 +/- 0.38 mm before to 2.69 +/- 0.37 mm after the stent implantation). Mean percent diameter stenosis decreased from 67.4 +/- 11.3% before to 18.9 +/- 7.7% after the intervention. A successful intervention (<50% diameter stenosis and no major adverse cardiac events within 30 days) occurred in 97% of the patients. The subacute thrombosis rate was 0.8%, which compares favorably with historical controls of this stent, and a low incidence of postprocedural increase in creatine kinase-MB was noted. At 6 months, event-free survival was 85% and angiographic restenosis rate was 22% with late loss of 0.78 +/- 0.69 mm and a loss index of 0.48 +/- 0.44. Heparin-coated Wiktor stents appeared to be an efficacious device to treat Benestent-like lesions, yielding angiographic and clinical results comparable to a heparin-coated Palmaz-Schatz stent. Despite its use in more complex lesions, the incidence of subacute thrombosis appeared to be lower than historical controls with a similar noncoated stent.

TABLE IV Cumulative Clinical Events at 30 Days, Six Months, and 12 Months in All 128 Patients With a Wiktor Hepamed Stent

TABLE VI Angiographic Data in Heparin-Coated Stent Trials

Hyperinsulinemia during oral glucose tolerance test is associated with increased neointimal tissue proliferation after coronary stent implantation in nondiabetic patients: a serial intravascular ultrasound study

(postintervention and six-month follow-up) intravascular ultrasound (IVUS) was used to study 67 lesions treated with Palmaz-Schatz stents in 55 nondiabetic patients. Cross-sectional images within stents were taken at every 1 mm, using an automatic pullback, and a neointimal index was calculated as the ratio between the averaged neointimal area and averaged stent area. All patients underwent a 75-g oral glucose tolerance test. Plasma glucose (PG) and immunoreactive insulin (IRI) levels were measured at baseline and 1 and 2 h after the glucose load. The sum of PGs (sigmaPG) and the sum of IIRIs (sigmaIRI) were calculated. Body mass index (BMI), lipid levels, and glycosylated hemoglobin levels were measured. RESULTS: There were 27 patients with normal glucose tolerance, and 28 patients with impaired glucose tolerance (IGT). The neointimal index in patients with IGT was greater than that in patients with normal glucose tolerance (42.9 +/- 14% vs. 24.9 +/- 8.3%, respectively, p < 0.0001). Linear regression analysis showed that the neointimal index at follow-up correlated well with sigmaPG (p < 0.0001), fasting IRI (p < 0.0001), sigmaIRI (p < 0.0001), triglyceride level (p = 0.018), and BMI (p < 0.0001). Multiple regression analysis revealed that sigmaIRI (p = 0.0002) and sigmaPG (p = 0.0034) were the best predictors of the greater neointimal index at follow-up. CONCLUSIONS: Serial IVUS assessment shows that hyperinsulinemia during an oral glucose tolerance test is associated with increased neointimal tissue proliferation after coronary stent implantation in nondiabetic patients.

Cath Cardiovasc Interv 2000 May;50(1):40-7

Clinical and angiographic follow-up after single long GFX coronary stent implantation


In order to identify predictors of late restenosis after GFX stent implantation, procedural and 6-month clinical and angiographic follow-up data of prospectively entered 141 consecutive lesions treated with a single long (24 or 30 mm) GFX stent were compared to 66 consecutive lesions requiring a single short (12 or 18 mm) stent. The initial clinical success rate of 97% and thrombosis rate of 1.4% with long stents were similar to 97% and 0% with short stents (P = NS). Their respective binary restenosis rates were 34.7% and 23.3% for long and short stents as a whole (P = NS), but being 10.0% for 12 mm, 26.0% for 18 mm, 31.3% for 24 mm, and 39.2% for 30 mm. When proximal and distal reference diameters at baseline were compared between the lesions with and without restenosis, proximal reference diameters were not statistically different (3.02+/-0.42 mm vs. 3.18+/-0.62 mm) and the restenosis group had significantly smaller distal reference diameters (2.15+/-0.48 mm vs. 2.55+/-0.53 mm, P<0.0001). The treatment of long lesions with single long-stent implantation can be accomplished with high
success and low complication rates. Single long-stent implantation may be effective, if the distal reference size of the long narrowing is big enough to accept the stent.

Am J Cardiol 2000 Aug;86(3):336-41

Usefulness of stent length in predicting in-stent restenosis (the MULTI-LINK stent trials)

Kereiakes D. Linnemeier TJ. Baim DS. Kuntz R. O’Shaughnessy C. Hermiller J. Fink S. Lansky A. Nishimura N. Broderick TM. Popma J.

The cumulative experience of 4 clinical trials using the MULTI-LINK coronary stent design was analyzed. Multivariable logistic regression identified postprocedure in-stent minimum lumen diameter (p = 0.0001), stent length (p = 0.0038), smoking (p = 0.0105), and diabetes (p = 0.0803) as the most important predictors of in-stent restenosis at late (6- to 9-month) angiographic follow-up.

TABLE V Predictors of In-Stent Restenosis

TABLE VI Prediction of Restenosis by Stent Length and Postprocedure In-Stent MLD from Multivariable Logistic Regression Analysis

Cath Cardiovasc Interv 2000 Apr;49(4):401-7

Angiographic and clinical outcome of a new self-expanding intracoronary stent (RADIUS): results from multicenter experience in Japan


The RADIUS coronary stent featuring a multisegmented slotted tube design and self-expanding nitinol delivery system has a high radial force and flexibility, uniform expansion, and contours to the shape of the vessel. Successful stent deployment was achieved in 104 stable angina patients (106 lesions; 44% LAD, 19%
circumflex, and 37% RCA). Mean minimal lumen diameter (MLD) increased from 0.77 +/- 0.46 mm to 2.88 +/- 0.61 mm and mean percent diameter stenosis (% DS) decreased from 73 +/- 14% to 6 +/- 13% immediately after the procedure. At 6-month follow-up, two patients (2%) underwent urgent target revascularization, and cerebral bleeding occurred in one patient (1%). Angiographic follow-up was performed in 94 lesions (89%) and mean MLD and mean % DS were 2.08 +/- 0.92 mm and 30% +/- 24%, respectively. Stent restenosis (>50% diameter stenosis at follow-up) was observed in 16 (17%) of all lesions. The high success rate for stent deployment, low incidence of major adverse cardiac event, and lower restenosis rate after stent implantation indicate that the RADIUS stent is useful for coronary intervention.

Cath Cardiovasc Interv 2000 Apr;49(4):376-81

Stenting for in-stent restenosis

Antoniucci D. Valenti R. Moschi G. Trapani M. Santoro GM. Bolognese L. Taddeucci E. Dovellini E.

Intravascular ultrasound studies have shown that additional stent implantation is the only percutaneous technique that allows for recovery of all the lumen area of the original implantation procedure. Despite this theoretical advantage, information on systematic additional stent implantation is still forthcoming, especially concerning the impact of new stent designs. This prospective study evaluated the efficacy of routine additional stent implantation for treatment of in-stent restenosis in 68 consecutive patients. Repeat stenting was successful in all cases, and second-generation tubular stents were used in 84% of patients. The mean additional stent length was 19.2 +/- 9.4 mm, and 15% of patients had multiple stent implantation. The postprocedure minimum lumen diameter was 3.11 +/- 0.41 mm, and the percentage residual stenosis was 2% +/- 7%. At a mean clinical follow-up of 10 +/- 8 months (follow-up rate 100%), the incidence of major adverse events was 21% (1 death, 13 target vessel revascularizations). Overall, angiographic restenosis rate was 32% (angiographic follow-up rate 79%). By multivariate analysis, the only predictors of recurrence after additional stenting were unstable angina at the second procedure (OR 8.70, 95% CI 1.50-50.33, P = 0.019), and early clinical recurrence after the first stent procedure (OR 4.83, 95% CI 1.13-20.71, P = 0.038). Additional stenting is a safe and effective treatment modality for the majority of patients with in-stent restenosis. Alternative treatments should be considered only for patients with in-stent restenosis presenting as unstable angina or early recurrence after a first stent procedure.

J Am Coll Cardiol 2000 May;35(6):1569-76
In-stent restenosis: long-term outcome and predictors of subsequent target lesion revascularization after repeat balloon angioplasty


OBJECTIVES: We sought to evaluate the long-term clinical outcome of patients undergoing successful balloon angioplasty for in-stent restenosis, and to determine correlates of the need for subsequent target lesion revascularization (TLR). BACKGROUND: In-stent restenosis can be safely treated by repeat percutaneous intervention. Reported subsequent TLR rates have varied from 20% to 80% and seem related to the type of restenotic lesion. METHODS: The study population comprised 234 patients with follow-up data who were successfully treated with repeat balloon angioplasty for in-stent restenosis in 257 lesions between May 1995 and January 1998 at our institution. RESULTS: Clinical follow-up was available at 459 (286 to 693) days after the repeat procedure. Event-free survival was 78.5% and 74.6% at 12 and 24 months, respectively. Recurrent events occurred in 58 patients (24.8%), including 6 deaths (2.6%), 4 myocardial infarction (1.7%) and repeat target vessel revascularization in 50 patients (21.4%). Independent predictors of repeat TLR were time to in-stent restenosis <90 days (Hazard ratio 4.67, p < 0.001), minimal luminal diameter after repeat procedure (Hazard ratio 0.38, p = 0.034) and the angiographic pattern of in-stent restenosis (Hazard ratio 1.65, p = 0.036). CONCLUSIONS: Balloon angioplasty is an effective means of treating in-stent restenosis. The long-term results are acceptable particularly for focal restenotic lesions. Further restenosis is more common in patients with early initial recurrence, more proliferative lesions and a poorer angiographic result from repeat angioplasty.

Am J Cardiol 2000 Aug;86(4):390-4

Six-month outcome after excimer laser coronary angioplasty for diffuse in-stent restenosis in native coronary arteries

Hamburger JN. Foley DP. de Feyter PJ. Wardeh AJ. Serruys PW
This study evaluated the intermediate-term follow-up after excimer laser coronary angioplasty (ELCA) and adjunctive percutaneous transluminal coronary angioplasty (PTCA) in patients with diffuse in-stent restenosis (lesion length > 10 mm). Clinical and angiographic follow-up were performed at 6 months. Quantitative coronary angiography performed at 3 stages—during stent implantation, before and after ELCA + PTCA, and at follow-up—included measurements of the minimum lumen diameter (MLD) and percent diameter stenosis (DS). Sixteen consecutive patients were included. The (median + range) stent length was 36 mm (range 15 to 105), with a restenotic lesion length of 32 mm (range 10 to 90). After ELCA + PTCA, the MLD increased from $0.60 \pm 0.41$ to $2.28 \pm 0.50$ mm, whereas the DS decreased from $76 \pm 16\%$ to $22 \pm 8\%$. Despite adjunctive high-pressure PTCA, the MLD after ELCA + PTCA remained smaller than the MLD after initial stent implantation, $(2.28 \pm 0.50 \text{ mm} \text{ vs } 2.67 \pm 0.32 \text{ mm}, p = 0.014)$. Adverse events included ELCA-related acute coronary occlusion in 4 patients and a per-procedural intracerebral hematoma in 1. At 6 months, there was recurrence of angina in all patients. Angiographic follow-up was completed in 13 patients (87%), showing a reocclusion in 6 (46%), a $> 50\%$ DS in 6 (MLD $1.03 \pm 0.87$ mm, DS $68 \pm 24\%$), and a distal de novo lesion in 1. Despite satisfactory acute angiographic results, the recurrence of significant restenosis in all patients suggests that ELCA + PTCA is not a suitable stand-alone therapy for diffuse in-stent restenosis of long stented segments.

FIGURE 1. Serial quantitative MLD measurements. I = post stent implantation; II = before ELCA; III = after ELCA + PTCA, IV = 6-month angiographic follow-up after ELCA + PTCA. Values are given as mean $\pm$ SD.

Heart. 2000 Sep;84(3):307-13

Clinical and angiographic outcome in patients with in-stent restenosis and repeat target lesion revascularisation in small coronary arteries

Gross CM. Kramer J. Weingartner O. Uhlich F. Dietz R. Waigand J

OBJECTIVE: To evaluate the clinical and angiographic outcome in patients with in-stent restenosis in small
coronary arteries and repeat target lesion revascularisation.

DESIGN: Patients with in-stent restenosis in coronary arteries ≤ 2.85 mm were eligible for the study and underwent target lesion revascularisation. Clinical and angiographic variables were assessed during a six month follow up period.

RESULTS: 73 patients with 79 lesions were treated by percutaneous transluminal coronary angioplasty (47%), excimer laser angioplasty (25%), or restenting (28%). The mean (SD) reference diameter before target lesion revascularisation was 2.12 (0.5) mm. Procedural success was achieved in all cases, but 57% of the patients had restenosis after six months. The rate of further restenosis was higher with laser angioplasty (78%) than with restenting (47%) or balloon angioplasty alone (49%, p < 0.05).

CONCLUSIONS: Treatment for in-stent restenosis in small coronary arteries is feasible and safe, with a second restenosis rate comparable to large coronary artery series. The strategy of target lesion revascularisation influences further in-stent restenosis, with an increased rate with laser angioplasty compared with restenting and repeat dilatation alone.

Table 5. Univariate analysis of predictors for second in-stent restenosis in 79 lesions

Objectives: To assess the influence of smoking on restenosis after coronary angioplasty.

DESIGN AND PATIENTS: The incidence of smoking on restenosis was investigated in 2948 patients. They were prospectively enrolled in four major restenosis trials in which quantitative angiography was used before and immediately after successful angioplasty and again at six months.

RESULTS: Within the study population there were 530 current smokers, 1690 ex-smokers, and 728 non-smokers. Smokers were more likely to be men (85.9% v 87.5% v 65.3%, current v ex-v non-, p < 0.001), to be younger (54.0 (9.0) v 57.0 (9.1) v 59.9 (9.4) years, p < 0.001), to have peripheral vascular disease (7.2% v 5.5% v 2.3%, p < 0.001),
and have sustained a previous myocardial infarction (42.9% v 43.9% v 37.9%, p = 0.022), but were less likely to be diabetic (9.1% v 9.5% v 12.6%, p = 0.043) or hypertensive (24.9% v 29.3% v 37.2, p < 0.001). There was no significant difference in the categorical restenosis rate (> 50% diameter stenosis) at six months (35.28% v 35.33% v 37.09%, current v ex-v non-), or the absolute loss (0.29 (0.54) v 0.33 (0.52) v 0.35 (0.55) mm, respectively; p = 0.172).

CONCLUSIONS: Although smokers have a lower incidence of known predisposing risk factors for atherosclerosis, they require coronary intervention almost six years earlier than non-smokers and three years earlier than ex-smokers. Once they undergo successful coronary angioplasty, there appears to be no evidence that smoking influences their short term (six month) outcome, but because of the known long term effects of smoking, patients should still be encouraged to discontinue the habit.

Figure 1. Cumulative distribution curve of clinical end points over time for current smokers, ex-smokers, and non-smokers

American Journal of Cardiology. 2000 Jun;85(12):1427-31

Predictors of clinical outcome following percutaneous intervention for in-stent restenosis


Percutaneous intervention for the first episode of in-stent restenosis was performed in 177 patients 5.4 ± 0.3 months after native coronary stent implantation. Medical records were reviewed and patients contacted 13.3 ± 1.2 months after in-stent intervention to ascertain the subsequent clinical course. The effects of demographic, procedural, and angiographic variables on clinical outcomes were determined. At 2 years, Kaplan-Meier estimated survival was 93 ± 3% and freedom from death, myocardial infarction, and a third target artery revascularization (TAR) was 67 ± 4%. The actuarial frequency of a third TAR was 26 ± 4% at 1 year. Stratification of outcomes according to timing of in-stent intervention revealed an approximate twofold higher frequency of adverse events among patients with early (≤3 months) in-stent restenosis. Advanced age (p = 0.019), prior coronary bypass (p = 0.017), and early in-stent intervention (p = 0.006) independently predicted increased mortality at follow-up. Systemic hypertension (p = 0.004), diabetes mellitus (p = 0.044), and early in-stent intervention (p <0.0001) independently predicted a third TAR. These variables (p = 0.007, p = 0.027, and p <0.0001, respectively) also independently predicted a composite end point consisting of death, myocardial
infarction, and a third TAR. No angiographic variable predicted outcome after in-stent intervention. Thus, long-term outcome following in-stent intervention was favorable. Early in-stent intervention, advanced age, hypertension, and diabetes predicted adverse outcomes.

TABLE IV Multivariate Analysis of Predictors of Outcomes

Am J Cardiol 2000 Jul;86(1):35-40

Detection of coronary restenosis by exercise electrocardiography thallium-201 perfusion imaging and coronary angiography in asymptomatic patients after percutaneous transluminal coronary angioplasty

Beygui F. Le Feuvre C. Maunoury C. Helft G. Antonietti T. Metzger JP. Vacheron A.

Noninvasive detection of restenosis in patients remaining asymptomatic after percutaneous transluminal coronary angioplasty (PTCA) remains a major clinical problem. The value of exercise electrocardiography (ECG) and exercise-redistribution thallium-201 single-photon emission computed tomography (SPECT) in detecting restenosis in such patients remains uncertain. Discordances between these tests and coronary angiography is a common situation. We studied 179 consecutive patients remaining asymptomatic after successful PTCA (208 vessels), who underwent 6 ± 2 months of exercise ECG, SPECT, and coronary angiography. We sought to assess the diagnostic value of the noninvasive tests compared with coronary angiography, and identify the determinants of discordances between the tests. Restenosis (diameter stenosis >50%) was detected in 39% of patients and in 37% of vessels. The overall sensitivity, specificity, and accuracy for exercise ECG and SPECT in detecting restenosis in individual vessels were, respectively, 53% versus 63% (p = 0.06), 59% versus 77% (p = 0.0001), and 57% versus 72% (p = 0.0001). On multivariate analysis, positive exercise ECG was associated with higher heart rate response (p = 0.02), incomplete revascularization (p = 0.004), and angiographic restenosis (p = 0.03), whereas positive SPECT was associated with incomplete revascularization (p = 0.02), infarct-related artery PTCA (p = 0.01), and angiographic restenosis (p = 0.0001). Accuracies of the 2 tests were not significantly different in patients with incomplete revascularization or PTCA of an infarct-related vessel. Overall, SPECT is more accurate than exercise ECG in detecting asymptomatic restenosis. Nevertheless, incomplete revascularization and PTCA of an infarct-related artery could cause reversible perfusion defects regardless of restenosis, reducing the diagnostic value of SPECT in such patients.
Effect of statin therapy on restenosis after coronary stent implantation

Walter DH. Schachinger V. Elsner M. Mach S. Auch-Schwelk W. Zeiher AM.

The effect of statins on the development of restenosis and clinical outcome after coronary stent implantation was assessed in a retrospective analysis of 525 consecutive patients. Baseline clinical, angiographic, and procedural characteristics did not differ between 258 patients with and 267 patients without statin therapy. Statin therapy was associated with a significantly \( p < 0.04 \) improved survival free of myocardial infarction and a significant reduction in repeat target vessel revascularization procedures (27.9% vs 36.7%, \( p < 0.05 \)) during 6-month follow-up. Minimal lumen diameter was significantly larger \( (1.98 \pm 0.88 \text{ vs } 1.78 \pm 0.88 \text{ mm}, p = 0.01) \), late lumen loss was significantly less \( (0.64 \pm 0.8 \text{ vs } 0.8 \pm 0.8 \text{ mm}, p = 0.032) \), and net gain significantly increased \( (1.2 \pm 0.88 \text{ vs } 0.98 \pm 0.92 \text{ mm}, p = 0.009) \) in patients receiving statin therapy. Dichotomous angiographic restenosis (≥50%) rates were significantly lower, with 25.4% in the statin group compared with 38% in the no-statin group \( (p < 0.005) \). Multivariate analysis identified statin therapy \( (p = 0.005) \), minimal lumen diameter immediately after stenting \( (p = 0.02) \), and stent length \( (p = 0.02) \) as independent predictors for subsequent restenosis development. Thus, statin therapy is associated with reduced recurrence rates and improved clinical outcome after coronary stent implantation.

TABLE IV Major Adverse Clinical Events at One- and Six-Month Clinical Follow-Up

FIGURE 1. Event-free survival. Long-term clinical adverse events (death due to cardiac causes and myocardial infarction [MI] of the target vessel) are compared by Kaplan-Meier survival curves and the corresponding \( p \) value obtained from the Cox regression model.

Treatment of in-stent restenosis with excimer laser coronary angioplasty versus rotational atherectomy: comparative mechanisms and results.

Background: Atheroablation yields improved clinical results for balloon angioplasty (percutaneous transluminal coronary angioplasty, PTCA) in the treatment of diffuse in-stent restenosis (ISR).

Methods and Results: We compared the mechanisms and clinical results of excimer laser coronary angioplasty (ELCA) versus rotational atherectomy (RA), both followed by adjunct PTCA; 119 patients (158 ISR lesions) were treated with ELCA+PTCA and 130 patients (161 ISR lesions) were treated with RA+PTCA. Quantitative coronary angiographic and planar intravascular ultrasound (IVUS) measurements were performed routinely. In addition, volumetric IVUS analysis to compare the mechanisms of lumen enlargement was performed in 28 patients with 30 lesions (16 ELCA+PTCA, 14 RA+PTCA). There were no significant between-group differences in preintervention or final postintervention quantitative coronary angiographic or planar IVUS measurements of luminal dimensions. Angiographic success and major in-hospital complications with the 2 techniques were also similar. Volumetric IVUS analysis showed significantly greater reduction in intimal hyperplasia volume after RA than after ELCA (43±14 versus 19±10 mm³, P <0.001) because of a significantly higher ablation efficiency (90±10% versus 76±12%, P =0.004). However, both interventional strategies had similar long-term clinical outcome; 1-year target lesion revascularization rate was 26% with ELCA+PTCA versus 28% with RA+PTCA (P =NS).

Conclusions: Despite certain differences in the mechanisms of lumen enlargement, both ELCA+PTCA and RA+PTCA can be used to treat diffuse ISR with similar clinical results.

Circulation. 2000 May;101(21):2478-83

Increased risk of restenosis after placement of gold-coated stents: results of a randomized trial comparing gold-coated with uncoated steel stents in patients with coronary artery disease


Background: Gold is a highly biocompatible material. Experimental evidence suggests that coating the stent with a gold layer may have a beneficial influence. In this randomized trial, we assessed whether gold-coated stents were associated with a better clinical and angiographic outcome after coronary placement.

Methods and Results: Patients with symptomatic coronary artery disease were randomly assigned to receive either a gold-coated Inflow stent (n=367) or an uncoated Inflow stainless steel stent (n=364) of identical design.
Follow-up angiography was routinely performed at 6 months. The primary end point of the study was the occurrence of any adverse clinical event (death, myocardial infarction, or target-vessel revascularization) during the first year after stenting. At 30 days, there was no significant difference in the combined incidence of adverse events, with 7.9% in the gold-stent group versus 5.8% in the steel-stent group (P =0.25). The incidence of angiographic restenosis (≥50% diameter stenosis) was 49.7% in the gold-stent group and 38.1% in the steel-stent group (P =0.003). One-year survival free of myocardial infarction was 88.6% in the gold-stent group and 91.8% in the steel-stent group (P =0.14). One-year event-free survival was significantly less favorable in the gold-stent group (62.9% versus 73.9% in the steel-stent group; P =0.001).

Conclusions: Coating steel stents with gold had no significant influence on the thrombotic events observed during the first 30 days after the intervention. However, gold-coated stents were associated with a considerable increase in the risk of restenosis over the first year after stenting.


Safety of intracoronary gamma-radiation on uninjured reference segments during the first 6 months after treatment of in-stent restenosis: a serial intravascular ultrasound study


Background: The effects of endovascular irradiation on uninjured reference segments during the treatment of in-stent restenosis are unknown.

Methods and Results: In the Washington Radiation for In-Stent restenosis Trial (WRIST), patients with in-stent restenosis were first treated with conventional catheter-based techniques and then randomized (blinded) to receive either [gamma]-irradiation (192Ir) or a placebo (dummy seeds). We identified all patients in whom the active (n=19) or dummy seeds (n=19) extended >10 mm proximal and distal to the in-stent restenosis lesion. Serial (postirradiation and follow-up) external elastic membrane (EEM), lumen, and plaque and media (EEM-lumen) areas were measured (using intravascular ultrasound) every 1 mm over 5-mm-long reference segments that were 6 to 10 mm proximal and distal to the in-stent restenosis lesion. During follow-up, a similar small increase occurred in the plaque and media area in the proximal and distal reference segments in both 192Ir and placebo patients. However, in the 192Ir patients, an increase in both proximal and distal EEM area occurred; as a result, no change in lumen area occurred. Conversely, in the placebo patients, the proximal reference EEM area decreased, and no change occurred in the distal reference EEM area; this contributed to a decrease in
lumen area.

Conclusions: There was no evidence of a deleterious effect of [gamma]-irradiation on angiographically normal uninjured reference segments in the first 6 months after the treatment of in-stent restenosis.

Figure 1. In the proximal reference artery, an increase in P&M area occurred in both 192Ir (0.7±1.1 mm²) and placebo (0.6±0.9 mm²) patients; these increases were similar (P=0.4). In the 192Ir group, EEM area increased (0.5±0.6 mm²), whereas in the placebo group, EEM area decreased (-0.6±0.7 mm²; P<0.0001 vs 192Ir). Thus, no significant decrease occurred in lumen area in the 192Ir group (-0.2±1.4 mm²); however, in the placebo group, lumen area did significantly decrease (-1.2±1.4 mm²; P=0.0002 vs 192Ir). In the distal reference artery, an increase in P&M area occurred in both the 192Ir (1.0±1.0 mm²) and placebo groups (0.9±0.9 mm²); these increases were similar (P=0.5). In the 192Ir group, EEM area increased (1.0±1.1 mm²), whereas in the placebo group, EEM area slightly decreased (-0.4±1.1 mm²; P<0.0001 vs 192Ir). As a result, in the 192Ir group, no change occurred in lumen area (0±1.3 mm²). In the placebo group, lumen area decreased (-1.2±1.1 mm²; P<0.0001 vs 192Ir). CSA indicates cross-sectional area.

Circulation. 2000 Apr;101(16):1895-8

Intracoronary beta-radiation therapy inhibits recurrence of in-stent restenosis.

Waksman R. Bhargava B. White L. Chan RC. Mehran R. Lansky AJ. Mintz GS. Satler LF. Pichard AD. Leon MB. Kent KK

Background: Intracoronary [gamma]-radiation therapy reduces recurrent in-stent restenosis (ISR). This study, BETA WRIST (Washington Radiation for In-Stent restenosis Trial) was designed to examine the efficacy and safety of the [beta]-emitter 90-yttrium for the prevention of recurrent ISR.

Methods and Results: A total of 50 consecutive patients with ISR in native coronaries underwent percutaneous transluminal coronary angioplasty, laser angioplasty, rotational atherectomy, and/or stent implantation. Afterward, a segmented balloon catheter was positioned and automatically loaded with a 90-yttrium, 0.014-inch source wire that was 29 mm in length to deliver a dose of 20.6 Gy at 1.0 mm from the balloon surface. In 17 patients, manual stepping of the radiation catheter was necessary for lesions >25 mm in length. The radiation was delivered successfully to all patients, with a mean dwell time of 3.0±0.4 minutes. Fractionation of the dose due to ischemia was required in 11 patients. At 6 months, the binary angiographic restenosis rate was 22%, the target lesion revascularization rate was 26%, and the target vessel revascularization rate was 34%; all rates were
significantly lower than those of the placebo group of [gamma]-WRIST.

Conclusions: [beta]-Radiation with a 90-yttrium source used as adjunct therapy for patients with ISR results in a lower-than-expected rate of angiographic and clinical restenosis

Table 1. Angiographic Results

<table>
<thead>
<tr>
<th>Values</th>
<th>No. of patients (%) or mean±SD.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM</td>
<td>left main artery</td>
</tr>
<tr>
<td>LAD</td>
<td>left anterior descending artery</td>
</tr>
<tr>
<td>LCX</td>
<td>left circumflex artery</td>
</tr>
<tr>
<td>RCA</td>
<td>right coronary artery</td>
</tr>
<tr>
<td>QCA</td>
<td>quantitative coronary angiography</td>
</tr>
</tbody>
</table>

Table 2. Clinical Events at 6 Months

<table>
<thead>
<tr>
<th>Values</th>
<th>No. of patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLR</td>
<td>target lesion revascularization</td>
</tr>
<tr>
<td>TVR</td>
<td>target vessel revascularization</td>
</tr>
<tr>
<td>CABG</td>
<td>coronary artery bypass grafting</td>
</tr>
<tr>
<td>PTCA</td>
<td>percutaneous transluminal coronary angioplasty</td>
</tr>
</tbody>
</table>

Am J Cardiol 2000 Feb;85(4):441-5

Intravascular ultrasonic predictors of angiographic restenosis after long coronary stenting

Hong MK. Park SW. Mintz GS. Lee NH. Lee CW. Kim JJ. Park SJ.

The intravascular ultrasound (IVUS) criteria for stent optimization have not been determined in stenting long lesions. We evaluated the predictors of angiographic restenosis and compared it with stent lumen cross-sectional area (CSA) and stent length between short (stent length <20 mm) and long (≥20 mm) coronary stenting. IVUS-guided coronary stenting was successfully performed in 285 consecutive patients with 304 native coronary lesions. Six-month follow-up angiogram was performed in 236 patients (82.8%) with 246 lesions (80.9%). Results were evaluated using conventional (clinical, angiographic, and IVUS) methods. The
overall angiographic restenosis rate was 22.8% (56 of 246 lesions) (short stent 17.6% vs long stent 32.2%, p = 0.009). Using multivariate logistic regression analysis, the independent predictors of angiographic restenosis were the IVUS stent lumen CSA (odds ratio 1.51, 95% confidence intervals 1.18 to 1.92, p = 0.001) and stent length (odds ratio 0.95, 95% confidence intervals 0.91 to 1.00, p = 0.039). The angiographic restenosis rate was 54.8% for stent lumen CSA of <5.0 mm² (short stent 37.5% vs long stent 73.3%, p = 0.049), 27.4% for CSA between 5.0 and 7.0 mm² (short stent 24.1% vs long stent 31.7%, p = 0.409), 10.5% for CSA between 7.0 and 9.0 mm² (short stent 10.0% vs long stent 12.5%, p = 0.772), and 11.4% for stent lumen CSA of ≥9.0 mm² (short stent 10.4% vs long stent 13.3%, p = 0.767) (p = 0.001). Compared with short coronary stenting, long coronary stenting is effective treatment modality to cover long lesions with comparable long-term clinical outcomes in cases of stent lumen CSA of ≥7.0 mm². Regardless of the stent length, the most important factor determining angiographic restenosis was the IVUS stent lumen CSA in relatively large coronary artery lesions.

TABLE V Angiographic and Intravascular Ultrasound (IVUS) Findings Between Restenosis and Non-Restenosis

TABLE VI Angiographic Restenosis Rate (%) According to Postintervention Lumen Cross-Sectional Area (CSA) and Stent Length

Stent and stent restenosis

1. Coronary artery stenting in the aged.
   Chauhan MS, Kuntz RE, Ho KL, Cohen DJ, Popma JJ, Carrozza JP Jr, Baim DS, Cutlip DE.
   J Am Coll Cardiol 2001 Mar 1;37(3):856-62

2. Preprocedural C-reactive protein levels and cardiovascular events after coronary stent implantation.
   Walter DH, Fichtlscherer S, Sellwig M, Auch-Schwelk W, Schachinger V, Zeiher AM.
   J Am Coll Cardiol 2001 Mar 1;37(3):839-46

3. Effect of ACE inhibitors on angiographic restenosis after coronary stenting (PARIS): a randomised, double-blind, placebo-controlled trial.
   Lancet 2001 Apr 28;357(9265):1321-4

4. Relationship between neointimal thickness and shear stress after Wallstent implantation in human coronary arteries.
   Circulation 2001 Apr 3;103(13):1740-5

5. Prolonged antiplatelet therapy to prevent late thrombosis after intracoronary gamma-radiation in patients with in-stent restenosis: Washington Radiation for In-Stent Restenosis Trial plus 6
months of clopidogrel (WRIST PLUS).


Circulation 2001 May 15;103(19):2332-5


Circulation 2001 May 1;103(17):2130-2


J Am Coll Cardiol 2001 May;37(6):1598-603

8. Treatment of Chlamydia pneumoniae infection with roxithromycin and effect on neointima proliferation after coronary stent placement (ISAR-3): a randomised, double-blind, placebo-controlled trial.


Lancet 2001 Jun 30;357(9274):2085-9

9. Incidence of thrombotic occlusion and major adverse cardiac events between two and four weeks after coronary stent placement: analysis of 5,678 patients with a four-week ticlopidine regimen.

Schuhlen H, Kastrati A, Pache J, Dirschinger J, Schomig A.

J Am Coll Cardiol 2001 Jun 15;37(8):2066-73


J Am Coll Cardiol 2001 Jun 15;37(8):2059-65

11. Intracoronary stenting and angiographic results: strut thickness effect on restenosis outcome (ISAR-STEREO) trial.


Circulation 2001 Jun 12;103(23):2816-21


J Am Coll Cardiol 2001 Jun 1;37(7):1877-82

13. Long-term (> or =8 years) outcome after Palmaz-Schatz stent implantation.
   Am J Cardiol 2001 Jul 1;88(1):10-6

15. Extent and distribution of in-stent intimal hyperplasia and edge effect in a non-radiation stent population.
   Han RO, Schwartz RS, Kobayashi Y, Wilson SH, Mann JT, Sketch MH, Safian RD, Lansky A, Popma J,
   Fitzgerald PJ, Palacios IF, Chazin-Caldie M, Goldberg S; Stent Comparative Restenosis (SCORES)
   Trial Investigators.
   Am J Cardiol 2001 Aug 1;88(3):253-9

16. Randomized comparison of coronary stent implantation under ultrasound or angiographic guidance to
    reduce stent restenosis (OPTICUS Study).
   V, Regar E, Henneke KH, Schachinger V, Zeiher A; OPTICUS (OPTimization with ICUS to
   reduce stent restenosis) Study Investigators.
   Circulation 2001 Sep 18;104(12):1343-9

17. Does stent design affect probability of restenosis? A randomized trial comparing Multilink stents with GFX
    stents.
   Am Heart J 2001 Sep;142(3):445-51

18. Randomised comparison of coronary stenting with and without balloon predilatation in selected patients.
   Bedossa M; Stent Without Balloon Predilation (SWIBAP) Study Group.
   Heart 2001 Sep;86(3):302-8

19. The TRAPIST Study. A multicentre randomized placebo controlled clinical trial of trapidil for prevention of
    restenosis after coronary stenting, measured by 3-D intravascular ultrasound.
   Serruys PW, Foley DP, Pieper M, Kleijne JA, de Feyter on behalf of the TRAPIST investigators PJ.

20. Direct coronary stenting without balloon or device pretreatment: acute success and long-term results.
    Stys T, Lawson WE, Liuzzo JP, Hanif B, Bragg L, Cohn PF.

21. Stent placement compared with balloon angioplasty for small coronary arteries: in-hospital and 6-month
    clinical and angiographic results.
22. Stent placement to prevent restenosis after angioplasty in small coronary arteries.

Circulation 2001 Oct 23;104(17):2029-33

23. Stenting in small coronary arteries (SISCA) trial. A randomized comparison between balloon angioplasty and the heparin-coated beStent.

J Am Coll Cardiol 2001 Nov 15;38(6):1598-603


J Am Coll Cardiol 2001 Nov 1;38(5):1434-9

25. Predictors of length of stay after coronary stenting.

Aronow HD, Peyser PA, Eagle KA, Bates ER, Werns SW, Russman PL, Crum MA, Harris K, Moscucci M.

26. The impact of high pressure vs low pressure stent implantation on intimal hyperplasia and follow-up lumen dimensions; results of a randomized trial.

Eur Heart J 2001 Nov;22(21):2015-24


J Am Coll Cardiol 2001 Nov 1;38(5):1434-9

28. Cost-effectiveness of coronary stenting in acute myocardial infarction: results from the stent primary angioplasty in myocardial infarction (stenPAMI) trial.

Cohen DJ, Taira DA, Berezin R, Cox DA, Morice MC, Stone GW, Grines CL.
Circulation 2001 Dec 18;104(25):3039-45

29. Complete or incomplete percutaneous coronary revascularization in patients with unstable angina in stent era: Are early and one-year results different?


30. Statin therapy, inflammation and recurrent coronary events in patients following coronary stent implantation.


Am Coll Cardiol 2001 Dec;38(7):2006-12

31. Coronary stenting in diabetic patients: Results from the ROSETTA registry.


Am Heart J 2001 Dec;142(6):960-4

32. A randomized comparison of direct stenting with conventional stent implantation in selected patients with acute myocardial infarction.

Loubeyre C, Morice MC, Lefevre T, Piechaud JF, Louvard Y, Dumas P.

J Am Coll Cardiol 2002 Jan 2;39(1):15-21


Lowe HC, Oesterle SN, Khachigian LM..

J Am Coll Cardiol 2002 Jan 16;39(2):183-93


Lowe HC, Oesterle SN, Khachigian LM..

J Am Coll Cardiol 2002 Jan 16;39(2):183-93

35. Use of localised intracoronary beta radiation in treatment of in-stent restenosis: the INHIBIT randomised controlled trial.


Lancet 2002 Feb 16;359(9306):551-7

36. The effect of completeness of revascularization on event-free survival at one year in the arts trial.


J Am Coll Cardiol 2002 Feb 20;39(4):559-64

37. Early and sustained survival benefit associated with statin therapy at the time of percutaneous coronary intervention.

Chan AW, Bhatt DL, Chew DP, Quinn MJ, Moliterno DJ, Topol EJ, Ellis SG.

Circulation 2002 Feb 12;105(6):691-6

38. Long-term efficacy of platelet glycoprotein IIb/IIIa integrin blockade with eptifibatide in coronary stent intervention.

O’Shea JC, Buller CE, Cantor WJ, Chandler AB, Cohen EA, Cohen DJ, Gilchrist IC, Kleiman NS,


J Am Coll Cardiol 2002 Feb 6;39(3):393-9

40. Fate of Lesion-Related Side Branched After Coronary Artery Stenting

David L. Fischman, MD, Michael P. Savage, MD, FACC, Martin B. Leon, MD, FACC, Richard A Schatz, MD, FACC, Stephen Ellis, MD, FACC, Michael W. Cleman, MD, FACC, John W. Hirshfield, MD, FACC, Paul Teirstein, MD, FACC, Steven Bailey, MD, FACC, Craig M. Walker, MD, FACC, Sheldon Goldberg, MD, FACC

J Am Coll Cardiol 1993;22:1641-6

41. Intracoronary stenting for acute and threatened closure complicating percutaneous transluminal coronary angioplasty

GS Roubin, AD Cannon, SK Agrawal, PJ Macander, LS Dean, WA Baxley and J Brelain Division of Cardiovascular Disease, University of Alabama, Birmingham 35294.

Circulation, Vol 85, 916-927

42. A Comparison of Balloon-Expandable-Stent Implantation with Balloon Angioplasty in Patients with Coronary Artery Disease

Patrick W. Serruys, Peter de Jaegere, Ferdinand Kiemeneij, Carlos Macaya, Wolfgang Rutsch, Guy Heyndrickx, Hakan Emanuelsson, Jean Marco, Victor Legrand, Pierre Materne, Jorge Belardi, Ulrich Sigwart, Antonio Colombo, Jean Jacques Goy, Paul van den Heuvel, Juan Delcan, Marie-angele Morel, for the Benestent Study Group


43. Small Stent Size and Intimal Hyperplasia Contribute to Restenosis: A Volumetric Intravascular Ultrasound Analysis

Gaston R. Dussaillant, MD, Gary S. Mintz, MD, FACC, Augusto D. Pichard, MD, FACC, Kenneth M. Kent, MD, PhD, FACC, Lowell F. Salter, MD, FACC, Jeffrey J. Poma, MD, FACC, S. Chiu Wong, MD, FACC, Martin B. Leon, MD, FACC

J Am Coll Cardiol 1995;26:720-4

44. Immediate Results and Late Outcomes After Stent Implantation in Saphenous Vein Graft Lesions: The Multicenter U.S. Palmaz-Schatz Stent Experience
45. Coronary Stenting for Treatment of Ostial Stenoses of Native Coronary Arteries or Aortocoronary Saphenous Vein Grafts

Krishna Rocha-Singh, MD, Nancy Morris, RN, S. Chiu Wong, MD, Richard A. Schatz, MD, and Paul S. Teirstein, MD

J Am Cardiol 1995;75:26-29

46. Continued Benefit of Coronary Stenting Versus Balloon Angioplasty: One-Year Clinical Follow-Up of Benestent Trial

Carlos Macaya, MD, Patrick W. Serruys, MD, FACC, Peter Ruygrok, MD, Harry Suryapranata, MD, Gijs Mast, MD, Silvio Klugmann, MD, Philippe Urban, MD, Peter den Heijer, MD, Karel Koch, MD, Rudiger Simon, MD, Marie-Claude Morice, MD, Peter Crean, MD, Hans Bonnier, MD, William Wijns, MD, Nicolas Danchin, MD, Claud Bourdonnec, MD, Marie-Angele Morel, Msc, for the BENESTENT Study Group

J Am Coll Cardiol 1996;27:255-61

47. Three-Year Follow-Up after Implantation of Metallic Coronary-Artery Stents

Takeshi Kimura, Hiroyoshi Yokoi, Yoshihisa Nakagawa, Takashi Tamura, Satoshi Kaburagi, Yoshihiro Sawada, Yasukazu Sato, Hiroatsu Yokoi, Naoya Hamasaki, Hideyuki Nosaka, Masakiyo Nobuyoshi


48. Incidence and Angiographic Predictors of Side Branch Occlusion Following High-Pressure Intracoronary Stenting

Darius Aliabadi, MD, Frank V. Tilli, MD, Terry R. Bowers, MD, Keith H. Benzuly, MD, Robert D. Safian, MD, James A. Goldstein, MD, Cindy L. Grimes, MD, William W. O’Neill, MD

The American Journal of Cardiology, 80:8:994-997

49. Restenosis Rates in Diabetic Patients: A Comparison of Coronary Stenting and Balloon Angioplasty in Native Coronary Vessels

Eric Van Belle, Christophe Bauters, Edouard Hubert, Jean-Christophe Bodart, Kaveh Abolmaali, Thibaud Meurice, Eugene P. McFadden, Jean-Marc Lablanche, and Michel E. Bertrand


50. Nine-year follow-up of balloon-expandable Palmaz-Schatz stent in patients with single-vessel disease
51. Comparison of Outcome After Stenting for De Novo Versus Restenotic Narrowings in Native Coronary Arteries

Suneet Mittal, MD, Debra L. Weiss, RN, MSN, John W. Hirshfeld, Jr., MD, Daniel M. Kolansky, MD, Howard C. Herrmann, MD

The American Journal of Cardiology, 80:6:711-715

52. Outpatient Coronary Stent Implantation

Ferdinand Kiemeneij, MD, PhD, Gert Jan Laarman, MD, PhD, Ton Slagboom, MD, Ron van der Wieken, MD

Journal of the American College of Cardiology, 29:2:323-327

53. Multivessel Palmaz-Schatz Stenting: Early Results and One-Year Outcome

Roger J. Laham, MD, Kalon K. L. Ho, MD, MSc, FACC, Donald S. Baim, MD, FACC, Richard E. Kuntz, MD, MSc, FACC, David J. Cohen, MD, MSc, Joseph P. Carrozza, MD, FACC, Jr.

Journal of the American College of Cardiology, 30:1:180-185

54. Acute and 30-Day Results of the Serpentine Balloon Expandable Stent Implantation in Simple and Complex Coronary Arterial Narrowings

Ariel Roguin, MD, Ehud Grenadier, MD, Benjamin Peled, MD, Walter Markiewicz, MD, Rafael Beyar, MD, DSc


55. Effects of Coronary Stenting on Restenosis and Occlusion After Angioplasty of the Culprit Vessel in Patients With Recent Myocardial Infarction

Christophe Bauters, Jean-Marc Lablanche, Eric Van Belle, Rodica Niculescu, Thibaud Meurice, Eugene P. McFadden, and Michel E. Bertrand


56. Percutaneous Transluminal Septal Myocardial Ablation in Hypertrophic Obstructive Cardiomyopathy: Acute Results and 3-Month Follow-Up in

Hubert Seggewiss, MD, Ulrich Gleichmann, MD, Lothar Faber, MD, Dieter Fassbender, MD, Henning K. Schmidt, MD, Stefan Strick, MD

Journal of the American College of Cardiology, 31:2:252-258

57. D Allele of the Angiotensin I-Converting Enzyme Is a Major Risk Factor for Restenosis After Coronary Stenting

Carole Amant, BS; Christophe Bauters, MD; Jean-Christophe Bodart, MD; Jean-Marc Lablanche, MD; Gilles Grollier, MD; Nicolas Danchin, MD; Martial Hamon, MD; Florence Richard, MD; Nicole Helbecque, PhD; Eugene P. McFadden, MRCPI; Philippe Amouyel, MD, PhD; Michel E. Bertrand, MD
58. Predictive Factors of Restenosis After Coronary Stent Placement
   Adnan Kastrati, MD, Albert Schomig, MD, Shpend Elezi, MD, Helmut Schuhlen, MD, Josef Dirschinger, MD, Martin Hadamitzky, MD, Franz-Josef Neumann, MD.
   J Am Coll Cardiol 1997;30:1428-36

59. Coronary artery stenting in the elderly: short-term outcome and long-term angiographic and clinical follow-up
   Joseph De Gregorio, Yoshio Kobayashi, Remo Albiero, Bernhard Reimers, Carlo Di Mario, Leo Finci, Antonio Colombo
   Journal of the American College of Cardiology, 32:3:577-583

60. The influence of diabetes mellitus on acute and late clinical outcomes following coronary stent implantation
   Alexandre Abizaid, Ran Kornowski, Gary S. Mintz, Mun H. Hong, Andrea S. Abizaid, Roxana Mehran, Augusto D. Pichard, Kenneth M. Kent, Lowell F. Satler, Hongsheng Wu, Jeffrey J. Popma, Martin B. Leon
   Journal of the American College of Cardiology, 32:3:584-589

61. Diabetes mellitus and the clinical and angiographic outcome after coronary stent placement
   Shpend Elezi, Adnan Kastrati, Jurgen Pache, Anne Wehinger, Martin Hadamitzky, Josef Dirschinger, Franz-Josef Neumann, Albert Schomig
   Journal of the American College of Cardiology, 32:7:1866-1873

62. Coronary wallstents show significant late, postprocedural expansion despite implantation with adjunct high-pressure balloon inflations
   Clemens von Birgelen, Segei G. Airiian, Pim J. de Feyter, David P. Foley, Wim J. van der Giessen, Patrick W. Serruys
   The American Journal of Cardiology, 82:2:129-134

63. Diabetes mellitus and the clinical and angiographic outcome after coronary stent placement
   Shpend Elezi, Adnan Kastrati, Jurgen Pache, Anne Wehinger, Martin Hadamitzky, Josef Dirschinger, Franz-Josef Neumann, Albert Schomig
   Journal of the American College of Cardiology, 32:7:1866-1873

64. Immediate and long-term outcomes of rotational atherectomy versus balloon angioplasty alone for treatment of diffuse in-stent restenosis
   Sang-Gon Lee, Cheol Whan Lee, Sang-Sig Cheong, Myeong-Ki Hong, Jae-Joong Kim, Seong-Wook Park, Seung-Jung Park
   The American Journal of Cardiology, 82:2:140-143

65. Six-Month Angiographic Outcome After Successful Repeat Percutaneous Intervention for In-Stent Restenosis
   Christophe Bauters, Jean-Luc Banos, Eric Van Belle, Eugene P. Mc Fadden, Jean-Marc Lablanche, and
66. Efficacy of Coronary Stenting Versus Balloon Angioplasty in Small Coronary Arteries
   Michael P. Savage, MD, FACC, David L. Fischman, MD, FACC, Randal Rake, BS, Martin B. Leon, MD, FACC, Richard A. Schatz, MD, FACC, Ian Penn, MD, FACC, Masakyo Nobuyoshi, MD, FACC, Jeffrey Moses, MD, FACC, John Hirshfeld, MD, FACC, Richard Heuser, MD, FACC, Donald Baim, MD, FACC, Michael Cleman, MD, FACC, Jeffrey Brinker, MD, FACC, Sharon Gebhardt, RN, Sheldon Goldberg, MD, FACC for the Stent Restenosis Study (STRESS) Investigators
   Journal of the American College of Cardiology, 31:2:307-311

67. Stenting in acute coronary syndromes: a comparison of radial versus femoral access sites
   Tift Mann, Gabriela Cubeddu, Josie Bowen, Joel E. Schneider, Michael Arrowood, William N. Newman, Michael J. Zellinger, Gregory C. Rose
   Journal of the American College of Cardiology, 32:3:572-576

68. Predictors of Restenosis After Coronary Stent Implantation
   Christophe Bauters, MD, FACC, Edouard Hubert, MD, Alain Prat, MD, Karim Bougrimi, MD, Eric Van Belle, MD, Eugene P. McFadden, MRCPI, FACC, Philippe Amouyel, MD, Jean-Marc Lablanche, MD, FACC, Michel Bertrand, MD, FACC
   Journal of the American College of Cardiology, 31:6:1291-1298

69. Comparison of the sheath delivery system versus bare stenting for coronary stent implantation
   Shunji Kasaoka, Rirei Son, Mahmoud Eslami, Clare Pierman, Jesse Currier, Lawrence A. Yeatman, Jonathan M. T

70. The influence of diabetes mellitus on acute and late clinical outcomes following coronary stent implantation
   Alexandre Abizaid, Ran Kornowski, Gary S. Mintz, Mun K. Hong, Andrea S. Abizaid, Roxana Mehran, Augusto D. Pichard, Kenneth M. Kent, Lowell F. Satler, Hongsheng Wu, Jeffrey J. Popma, Martin B. Leon
   Journal of the American College of Cardiology, 32:3:584-589

71. Coronary stenting in the elderly: Longitudinal results in a wide spectrum of patients treated with a new and more practical approach

72. Nonischemic Chest Pain Induced by Coronary Interventions: A Prospective Study Comparing Coronary Angioplasty and Stent Implantation
   Allen Jeremias, Sven Kutscher, Michael Haude, Dagmar Heinig, Gerald Holtmann, Wolfgang Senf, and Raimund Erbel
73. One-Year Follow-Up of The Stent Restenosis (STRESS I) Study
Charles J. George, MS, Donald S. Baim, MD, Jeffrey A. Brinker, MD, David L. Fischman, MD, Sheldon Goldberg, MD, Richard Holubkov, PhD, Elizabeth D. Kennard, PhD, Lisa Veltri, MS, Katherine M. Detre, MD, DrPH
The American Journal of Cardiology, 81:7:860-865

74. Optimal coronary balloon angioplasty with provisional stenting versus primary stent (OCBAS) : Immediate and long-term follow-up results
Alfredo Rodriguez, Francisco Ayala, Victor Bernardi, Omar Santaera, Eugenio Marchand, Cesar Pardinas, Carlos Mauvecin, Daniel Vogel, Lari C. Harrell, Igor F. Palacios on behalf of the OCBAS investigators
Journal of the American College of Cardiology, 32:5:1351-1357

75. Interlesion Dependence of the Risk for Restenosis in Patients With Coronary Stent Placement in Multiple Lesions
Adnan Kastrati, Albert Schomig, Shpend Elezi, Helmut Schuhlen, Manfred Wilhelm, and Josef Dirschinger

76. Influence of lesion length on restenosis after coronary stent placement
Adnan Kastrati, Shpend Elezi, Josef Dirschinger, Martin Hadamitzky, Franz-Josef Neumann, Albert Schomig
The American Journal of Cardiology, 83:12:1617-1622

77. Mechanisms of Residual Lumen Stenosis After High-Pressure Stent Implantation : A Quantitative Coronary Angiography and Intravascular Ultrasound Study
Javier Bermejo, Javier Botas, Eulogio Garcia, Jaime Elizaga, Julio Osende, Javier Soriano, Manuel Abeytua, and Juan Luis Delcan

78. Intracoronary Stenting and Risk for Major Adverse Cardiac Events During the First Month
Helmut Schuhlen, Adnan Kastrati, Josef Dirschinger, Jorg Hausleiter, Shpend Elezi, Anne Wehinger, Jurgen Pache, Martin Hadamitzky, and Albert Schomig

79. Balloon angioplasty for the treatment of coronary in-stent restenosis: immediate results and 6-month angiographic recurrent restenosis rate
Helene Eltchaninoff, Rene Koning, Christophe Tron, Vivek Gupta, Alain Cribier
Journal of the American College of Cardiology, 32:4:980-984

80. Fatal cardiac rupture among patients treated with thrombolytic agents and adjunctive thrombin antagonists : Observations from the Thrombolysis and Thrombin Inhibition in Myocardial
Infarction 9 Study

Richard C. Becker, Judith S. Hochman, Christopher P. Cannon, Frederick A. Spencer, Steven P. Ball, Michael J. Rizzo, Elliott M. Antman for the TIMI 9 Investigators

Journal of the American College of Cardiology, 1999; 33:2:479-487

81. Impact of Intravascular Ultrasound Guidance in Stent Deployment on 6-Month Restenosis Rate: A Multicenter, Randomized Study Comparing Two Strategies - With and Without Intravascular Ultrasound Guidance

François Schiele, MD, Nicolas Meneveau, MD, Alain Vuillemenot, MD, Da Dong Zhang, MD, Sanjiv Gupta, MD, Mariette Mercier, MD, Nicloas Danchin, MD, FACC, FESC, Bernard Bertrand, MD, Jean-Pierre Bassand, MD, FACC, FESC, on behalf of the RESIST Study Group

J Am Coll Cardiol 1998;32:320-8

82. Comparison of Angiographic and Clinical Outcomes of Coronary Stenting of Chronic Total Occlusions Versus Subtotal Occlusions

Issam Moussa, MD, Carlo Di Mario, MD, Jeffrey Moses, MD, Bernhard Reimers, MD, Lucia Di Francesco, PhD, Simonetta Blengino, MD, and Antonio Colombo, MD

Am J Cardiol 1998;81:1-6

83. Stent Implantation Versus Balloon Angioplasty in Chronic Coronary Occlusions: Results From the GISSOC Trial

Paolo Rubartelli, MD, Luigi Niccoli, MD, Edoardo Verna, MD, Corinna Giachero, MD, Marco Zimarino, MD, Alessandro Fontanelli, MD, Corrado Vassanelli, MD, Luigi Campolo, MD, Eugenio Martuscelli, MD, Giorgio Tommasini, MD, for the Gruppo Italiano Di Studio sullo Stent nelle Occlusioni Coronariche (GISSOC)

Genoa, Brescia, Varese, Gualdo Tadino, Udine, Verona, Milan, Rome and Treviglio, Italy

Am J Cardiol 1998;32:90-6

84. Effects of probucol and cilostazol alone and in combination on frequency of poststenting restenosis

Michihito Sekiya, Junichi Funada, Kouki Watanabe, Masao Miyagawa, Hiroshi Akutsu

The American Journal of Cardiology, 1998;82:2:144-147

85. Randomised comparison of implantation of heparin-coated stents with balloon angioplasty in selected patients with coronary artery disease (Benestent II)


Lancet 1998; 352: 67381

86. Early Lumen Loss After Treatment of In-Stent Restenosis: An Intravascular Ultrasound Study

Avinoam Shiran, Gary S. Mintz, Ron Waksman, Roxana Mehran, Andrea Abizaid, Kenneth M. Kent,
87. Comparison of Aggressive Versus Nonaggressive Balloon Dilatation for Stent Deployment on Late Loss and Restenosis in Native Coronary Arteries

Steven L. Goldberg, MD, Carlo Di Mario, MD, Patrick Hall, MD., Antonio Colombo, MD


88. Direct stent implantation without predilatation using the multilink stent

Dimitrios Pentousis, Yves Guerin, Francois Funck, Hong Zheng, Marcel Toussaint, Thierry Corcos, Xavier Favreau

The American Journal of Cardiology, 1998;82:12:1437-1440

89. Impact of an aggressive coronary stenting strategy on the incidence of target lesion revascularization

Ahmad Farshid, Roger M. Allan, Robert W. Giles, R. Michael McCredie, Mark R. Pitney, Warren F. Walsh

The American Journal of Cardiology, 1998;82:12:1441-1444

90. Effects of cilostazol on late lumen loss after Palmaz-Schatz stent implantation

Masao Yamasaki, Kazuhiro Hara, Yuji Ikari, Nobuyuki Kobayashi, Ken Kozuma, Yuki Ohmoto, Yoshio Oh-Hashi, Junya Ako, Hiro yoshi Nakajima, Noriyasu Chiku, Fumihiko Saeki, Tsutomu Tamura


91. Direct coronary stenting without predilatation: A new therapeutic approach with a special balloon catheter design

Hans R. Figulla, Harald Mudra, Nicolaus Reifart, Gerald S. Werner


92. n-3 fatty acids do not prevent restenosis after coronary angioplasty: results from the CART study

Odd Johansen, Magne Brekke, Ingebjorg Seljeflot, Michael Abdelnoor, Harald Arnesen

Journal of the American College of Cardiology, 33:6:1619-1626

93. Pathology of Acute and Chronic Coronary Stenting in Humans


94. Sustained benefit of stenting chronic coronary occlusion: long-term clinical follow-up of the Stenting in Chronic Coronary Occlusion (SICCO) study

Per Anton Sirnes, Svein Golf, Yngvar Myreng, Per Mølstad, Per Albertsson, Arild Mangschau, Knut Endresen, John Kjekshus

Journal of the American College of Cardiology, 32:2:305-310

95. In-Stent Neointimal Proliferation Correlates With the Amount of Residual Plaque Burden Outside the
Stent: An Intravascular Ultrasound Study
Francesco Prati, Carlo Di Mario, Issam Moussa, Bernhard Reimers, Maria Teresa Mallus, Antonio Parma, Ernesto Lioy, and Antonio Colombo

96. Safety and Efficacy of Ticlopidine for Only 2 Weeks After Successful Intracoronary Stent Placement
Peter B. Berger, Malcolm R. Bell, David Hasdai, Diane E. Grill, Steve Melby, and David R. Holmes, Jr

97. Predictors of long-term outcome after stent implantation in a saphenous vein graft
Michel R. Le May, Marino Labina, Jean-Francois Marquis, Louise A. Laramee, Edward R. O’Brien, William L. Williams, Jennifer L. Jelley, Kirsten Woodend, Lyall A. Higginson
The American Journal of Cardiology, 83:5:681-686

98. Comparison of Quantitative Coronary Angiography, Intravascular Ultrasound, and Coronary Pressure Measurement to Assess Optimum Stent Deployment

99. Prognostic Value of the Modified American College of Cardiology/American Heart Association Stenosis Morphology Classification for Long-Term Angiographic and Clinical Outcome After Coronary Stent Placement
Adnan Kastrati, Albert Schomig, Shpend Elezi, Josef Dirschinger, Julinda Mehilli, Helmut Schuhlen, Rudolf Blasini, and Franz-Josef Neumann
Circulation 1999 100: 1285-1290.

100. Pathology of Acute and Chronic Coronary Stenting in Humans

101. Plasma Lipoprotein(a) Is Not a Predictor for Restenosis After Elective High-Pressure Coronary Stenting
Flavio Ribichini, Giuseppe Steffenino, Antonio Dellavalle, Antonello Vado, Valeria Ferrero, Terenzio Camilla, Silvia Giubergia, and Eugenio Uslenghi

102. Immediate results and late clinical outcomes after new crossflex coronary stent implantation
Seung-Jung Park, Seong-Wook Park, Cheol Whan Lee, Myeong-Ki Hong, Jae-Joong Kim, Hoon-Ki Park, Mun K. Hong, Gary S. Mintz, Martin B. Leon
The American Journal of Cardiology, 1998;83:4:502-506

103. Acute Platelet Inhibition With Abciximab Does Not Reduce In-Stent Restenosis (ERASER Study)
The ERASER Investigators
(Circulation. 1999;100:799-806.)
104. Acute and nine-month clinical outcomes after "suboptimal" coronary stenting: Results from the STent anti-thrombotic regimen study (STARS) registry
Donald E. Cutlip, Martin B. Leon, Kalon K.L. Ho, Paul C. Gordon, Alessandro Giambartolomei, Daniel J. Diver, David M. Lasorda, David O. Williams, Michelle M. Fitzpatrick, April Desjardin, Jeffrey J. Popma, Richard E. Kuntz, Donald S. Baim for the STent Anti-thrombotic Regimen Study Investigators
Journal of the American College of Cardiology, 1999;34:3:698-706

104. Intracoronary serotonin release after high-pressure coronary stenting.
Am J Cardiol 1999 Dec 1;84(11):1317-22

105. Direct coronary stenting without predilation.
J Am Coll Cardiol 1999 Dec;34(7):1910-5

106. Long-term endothelial dysfunction after coronary artery stenting.
Caramori PR, Lima VC, Seidelin PH, Newton GE, Parker JD, Adelman AG
J Am Coll Cardiol 1999 Nov 15;34(6):1675-9

J Am Coll Cardiol 1999 Nov 1;34(5):1498-506

Circulation 1999 Nov 2;100(18):1872-8

Serruys PW, Kay IP, Disco C, Deshpande NV, de Feyter PJ

110. Baseline clinical and angiographic variables associated with long-term outcome after successful intracoronary stent implantation.
Mathew V, Grill DE, Scott CG, Garratt KN, Holmes DR Jr
Am J Cardiol 1999 Oct 1;84(7):789-94

111. Short- and long-term outcomes of Wiktor stent implantation at low versus high pressures. Austrian Wiktor Stent Study Group.
   Am J Cardiol 1999 Sep 15;84(6):644-9

112. Acute and nine-month clinical outcomes after “suboptimal” coronary stenting: results from the STent Anti-thrombotic Regimen Study (STARS) registry.
   J Am Coll Cardiol 1999 Sep;34(3):651-9

113. Stented segment length as an independent predictor of restenosis.
   Kobayashi Y, De Gregorio J, Kobayashi N, Akiyama T, Reimers B, Finci L, Di Mario C, Colombo A
   J Am Coll Cardiol 1999 Sep;34(3):651-9

114. Frequency and prognostic value of cardiac troponin I elevation after coronary stenting.
   Am J Cardiol 1999 Sep 1;84(5):515-8

115. Long-term outcome of patients with very long stents for treatment of diffuse coronary disease.
   Am Heart J 1999 Sep;138(3 Pt 1):441-5

116. Influence of lesion length on restenosis after coronary stent placement.
   Kastrati A, Elezi S, Dirschinger J, Hadamitzky M, Neumann FJ, Schomig A
   Am J Cardiol 1999 Jun 15;83(12):1617-22

117. Tissue proliferation within and surrounding Palmaz-Schatz stents is dependent on the aggressiveness of stent implantation technique.
   Hoffmann R, Mintz GS, Mehran R, Kent KM, Pichard AD, Satler LF, Leon MB
   Am J Cardiol 1999 Apr 15;83(8):1170-4

118. Long-term follow-up study of coronary reconstruction with multiple stents.
   Liu MW, Luo JF, Dean LS, Baxley WA, Iyer SS, Sutor RJ, Negus B, Roubin GS
   Am Heart J 1999 Feb;137(2):292-7

119. Effects of Probucol on Vascular Remodeling After Coronary Angioplasty
   Gilles Cote, Jean-Claude Tardif, Jacques Lesperance, Jean Lambert, Martial Bourassa, Raoul Bonan, Gilbert Gosselin, Michel Joyal, Jean-Francois Tanguay, Stanley Nattel, Richard Gallo, and Jacques Crepeau
   Circulation 1999 99: 30-35.
120. Stented segment length as an independent predictor of restenosis
Yoshio Kobayashi, Joseph De Gregorio, Nobuyuki Kobayashi, Tatsuro Akiyama, Bernhard Reimers, Leo Finci, Carlo Di Mario, Antonio Colombo
Journal of the American College of Cardiology, 34:3:651-659

121. Stents covered by autologous venous grafts: Feasibility and immediate and long-term results
Christodoulos Stefanadis, MD, FACC, FESC, Konstantinos Toutouzas, MD, Eleftherios Tsiamis, MD, Charalambos Vlachopoulos, MD, Ioannis Kallikazaros, MD, Costas Stratos, MD, Manolis Vavuranakis, MD, FACC, Pavlos Toutouzas, MD, FACC, FESC
Athens, Greece
(Am Heart J 2000;139:437-45.)

122. Treatment of Aortocoronary Vein Graft Lesions With Membrane-Covered Stents : A Multicenter Surveillance Trial
Stephan Baldus, Ralf Koster, Mathias Elsner, Dirk H. Walter, Roman Arnold, Wolfgang Auch-Schwelk, Jurgen Berger, Mathias Rau, Thomas Meinertz, Andreas M. Zeiher, and Christian W. Hamm

123. Stent placement for ostial left anterior descending coronary artery stenosis: Acute and long-term (2-year) results
Seung-Jung Park, Cheol Whan Lee, Myeong-Ki Hong, Jae-Joong Kim, Seong-Wook Park

124. Procedural results and late clinical outcomes after percutaneous interventions using long (25 mm) versus short (<20 mm) stents
Ran Kornowski, Balram Bhargava, D.M. Shmuel Fuchs, Alexandra J. Lansky, Lowell F. Satler, Augusto D. Pichard, Mun K. Hong, Kenneth M. Kent, Roxana Mehran, Gregg W. Stone, Martin B. Leon
Journal of the American College of Cardiology, 35:3:612-618

125. Influence of treatment modality on angiographic outcome after coronary stenting in diabetic patients: a controlled study
Joachim Schofer, Michael Schluter, Thomas Rau, Falk Hammer, Natalie Haag, Detlef G. Mathey
Journal of the American College of Cardiology, 2000;35:6:1554-1559

126. Immediate and late outcomes after direct stent implantation without balloon predilation
Journal of the American College of Cardiology, 2000;35:4:937-943

127. Long-term outcome in patients treated by intracoronary stenting with ticlopidine and aspirin, and deleterious prognostic role of unstable angina pectoris
Michael Angioi, Nicolas Danchin, Francois Alla, Catherine Gangloff, Henri Sunthorn, Rosa-Maria Rodriguez, Jean-Philippe Preiss, Alain Grentzinger, Philippe Houplon, Yves Juilliere,
Francois Cherrier
The American Journal of Cardiology, 85:9:1065-1070

128. Randomized Comparison of GR-II Stent and Palmaz-Schatz Stent for Elective Treatment of Coronary Stenoses

129. Nine-year follow-up of balloon-expandable Palmaz-Schatz stent in patients with single-vessel disease
Carma Karam, Jean Fajadet, Alain Beauchet, Bernard Cassagneau, Jean Marco

130. Long-term clinical events following creatine kinase-myocardial band isoenzyme elevation after successful coronary stenting
Jorge F. Saucedo, Roxana Mehran, George Dangas, Mun K. Hong, Alexandra Lansky, Kenneth M. Kent, Lowell F. Satler, Augusto D. Pichard, Gregg W. Stone, Martin B. Leon
Journal of the American College of Cardiology, 35:5:1134-1141

131. Balloon optimization versus stent study (BOSS): provisional stenting and early recoil after balloon angioplasty
George Dangas, John A. Ambrose, Diane Rehmann, Jonathan D. Marmur, Samin K. Sharma, Craig Hemdal-Monsen, Timothy A. Sanborn, David L. Fischman
The American Journal of Cardiology, 85:8:957-961

132. Comparison of debulking followed by stenting versus stenting alone for saphenous vein graft aortoostial lesions: immediate and one-year clinical outcomes
Journal of the American College of Cardiology, 2000;35:6:1560-1568

133. Effect of statin therapy on restenosis after coronary stent implantation
Dirk H. Walter, Volker Schachinger, Mathias Elsner, Stefan Mach, Wolfgang Auch-Schwelk, Andreas M. Zeiher
The American Journal of Cardiology, 2000;85:8:962-968

134. Fate of stent-related side branches after coronary intervention in patients with in-stent restenosis
Fernando Alfonso, Carlos Hernandez, Maria Jose Perez-Vizcayno, Rosana Hernandez, Antonio Fernandez-Ortiz, Javier Escaned, Camino Banuelos, Manel Sabate, Marcelo Sanmartin, Cristina Fernandez, Carlos Macaya
Journal of the American College of Cardiology, 2000;36:5:1549-1556

135. Procedural results and intermediate clinical outcomes after multiple saphenous vein graft stenting.

J Am Coll Cardiol 2000 Feb;35(2):389-97


Kini A, Marmur JD, Dangas G, Choudhary S, Sharma SK


137. Previous cytomegalovirus infection and risk of coronary thrombotic events after stent placement.

Neumann FJ, Kastrati A, Miethke T, Pogatsa-Murray G, Seyfarth M, Schomig A

Circulation 2000 Jan 4-11;101(1):11-3

138. Heparin-coated Wiktor stents in human coronary arteries (MENTOR trial)


Am J Cardiol 2000 Aug;86(4):385-9

139. Hyperinsulinemia during oral glucose tolerance test is associated with increased neointimal tissue proliferation after coronary stent implantation in nondiabetic patients: a serial intravascular ultrasound study

Takagi T, Yoshida K, Akasaka T, Kaji S, Kawamoto T, Honda Y, Yamamuro A, Hozumi T, Morioka S.

J Am Coll Cardiol 2000 Sep;36(3):731-8

140. Clinical and angiographic follow-up after single long GFX coronary stent implantation

Nakagawa Y, Yufu K, Nakamori S, Kimura T, Yokoi H, Tamura T, Hamasaki N, Nosaka H, Nobuyoshi M.

Cath Cardiovasc Interv 2000 May;50(1):40-7

141. Usefulness of stent length in predicting in-stent restenosis (the MULTI-LINK stent trials)


Am J Cardiol 2000 Aug;86(3):336-41

142. Angiographic and clinical outcome of a new self-expanding intracoronary stent (RADIUS): results from multicenter experience in Japan


Cath Cardiovasc Interv 2000 Apr;49(4):401-7

143. Stenting for in-stent restenosis


Cath Cardiovasc Interv 2000 Apr;49(4):376-81

144. In-stent restenosis: long-term outcome and predictors of subsequent target lesion revascularization after repeat balloon angioplasty

145. Six-month outcome after excimer laser coronary angioplasty for diffuse in-stent restenosis in native coronary arteries

Hamburger JN. Foley DP. de Feyter PJ. Wardeh AJ. Serruys PW
Am J Cardiol 2000 Aug;86(4):390-4

146. Clinical and angiographic outcome in patients with in-stent restenosis and repeat target lesion revascularisation in small coronary arteries

Gross CM. Kramer J. Weingartner O. Uhlich F. Dietz R. Waigand J
Heart. 2000 Sep;84(3):307-13

147. Influence of a history of smoking on short term (six month) clinical and angiographic outcome after successful coronary angioplasty

Violaris AG. Thury A. Regar E. Melkert R. Serruys PW
Heart. 2000 Sep;84(3):299-306

148. Predictors of clinical outcome following percutaneous intervention for in-stent restenosis

American Journal of Cardiology. 2000 Jun;85(12):1427-31

149. Detection of coronary restenosis by exercise electrocardiography thallium-201 perfusion imaging and coronary angiography in asymptomatic patients after percutaneous transluminal coronary angioplasty

Beygui F. Le Feuvre C. Maunoury C. Helft G. Antonietti T. Metzger JP. Vacheron A.
Am J Cardiol 2000 Jul;86(1):35-40

150. Effect of statin therapy on restenosis after coronary stent implantation

Walter DH. Schachinger V. Elsner M. Mach S. Auch-Schwelk W. Zeiher AM.
Am J Cardiol 2000 Apr;85(8):962-8


Circulation. 2000 May;101(21):2484-9

152. Increased risk of restenosis after placement of gold-coated stents: results of a randomized trial comparing gold-coated with uncoated steel stents in patients with coronary artery disease

Circulation. 2000 May;101(21):2478-83
153. Safety of intracoronary gamma-radiation on uninjured reference segments during the first 6 months after treatment of in-stent restenosis: a serial intravascular ultrasound study


Waksman R. Bhargava B. White L. Chan RC. Mehran R. Lansky AJ. Mintz GS. Satler LF. Pichard AD. Leon MB. Kent KK

Circulation. 2000 Apr;101(16):1895-8

155. Intravascular ultrasonic predictors of angiographic restenosis after long coronary stenting

Hong MK. Park SW. Mintz GS. Lee NH. Lee CW. Kim JJ. Park SJ.

Am J Cardiol. 2000 Feb;85(4):441-5