Postangioplasty Restenosis Rate Between Segments of the Major Coronary Arteries

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Conflicting data have been published regarding the rate of postangioplasty restenosis observed in diverse segments of the coronary tree. However, these studies may be criticized for their biased selection of patients, methods of analysis, and definitions of restenosis. In the present study, 1,353 patients underwent a successful coronary dilatation of ≥1 site. In all, 1,234 patients (91%) had a follow-up angiogram after 6 months, or earlier when indicated by symptoms. All films were processed and analyzed at the thoraxcenter core laboratory with the coronary angiography analysis system (automated contour detection). Restenosis was considered present if the diameter stenosis at follow-up was >50%. No differences in restenosis rates were observed between coronary segments using this categorical definition. A continuous approach was also used; absolute changes in minimal luminal diameter adjusted for vessel size were used in order to allow comparison between vessels of different sizes (relative loss). No significant differences were observed between the coronary segments with this continuous approach. These results suggest that restenosis is a ubiquitous phenomenon without any predilection for a particular site in the coronary tree.

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Ever since the introduction of percutaneous transluminal coronary angioplasty (PTCA)[1] as an alternative to coronary artery bypass grafting, this means of treatment has been plagued by the problem of restenosis, which has become an important field of investigation in interventional cardiology. During the last 14 years clinicians have searched extensively for factors increasing the risk of restenosis, and many patient-lesion-procedure–related factors have been put forward.[2,3] However, the cause and effect relation of these factors can be questioned, because these early studies were, in general, retrospective analyses with relatively small numbers of patients. In addition, these studies were fraught with methodologic problems; angiographic follow-up was incomplete, incidence of restenosis was influenced by the recurrence of symptoms, and time for restudy was not predetermined. Furthermore, the definition of restenosis varied between the different studies, and presence or absence of restenosis was assessed visually, a method known to be limited by inter- and intraobserver variability.[4,5] One risk factor for restenosis that led to controversy is the site of dilatation, with some studies finding a higher incidence of restenosis in the proximal left anterior descending coronary artery (LAD) as compared with the right or left circumflex coronary artery (LC) (Table I).[6-19] Recently, 2 multicenter restenosis prevention trials enrolled >1,400 patients who were analyzed at the same angiographic core laboratory. In 91% of these patients, follow-up angiography was performed, and the same quantitative coronary angiographic method of analysis was used.[5,20] The present study investigates whether the previously reported differences in restenosis rates in the 3 major coronary arteries could be confirmed in this large study group.

METHODS

The study population consisted of 1,442 patients with significant primary stenoses in native coronary arteries who were prospectively enrolled in 2 restenosis trials in Europe. Because no angiographic or clinical benefit of the 2 tested compounds could be demonstrated, the control and active treatment groups were pooled for the present study. PTCAs and follow-up films of all patients with successful dilations were analyzed at the thoraxcenter core laboratory. Informed consent was obtained in all cases before the PTCA procedure, and all patients were asked to return to the hospital for follow-up angiography. Patients with stable and unstable angina pectoris, and those with totally occluded vessel segments were included in the study. Pa-

TABLE I Summary of Restenosis Studies Demonstrating Conflicting Results as to the Site of Dilatation as a Risk Factor for Restenosis

Study	Year	Patients	Angio Fup (%)	Definition of Restenosis	Restenosis (%)	Coronary Artery	Statistical Analysis
Holmes[6]	1984	665	84	NHLBI I→IV	33.6	No difference	Multivariate
Kaltenbach[7]*	1985	356	94	DS Fup <20% DS pre	12	No difference	Univariate
				Decrease ≥50% of gain	16		
				↑ DS ≥30%	17		
Mata[8]†	1985	63	95	↑ DS >30% or DS >70%	23	LAD or LC >right	Multivariate
DiSciascio[9]†	1986	191	21¶	Decrease ≥50% of gain	58 1-VD 42 2-VD	No difference	Univariate
Leimgruber[10]	1986	1,758	57	>50% DS	30.2	LAD >right >LC	Multivariate
Myler[11]‡	1987	286	57	>50% DS	41	No difference	Multivariate
Val[12]	1987	181	98	↑ ≥30% DS	28	No difference	Multivariate
Vandormael[13]‡	1987	209	62	>50% DS	82 (Symp) 30 (No Symp)	LAD >right or LC Prox >Dist	Multivariate
Black[14]§	1988	384	39	>50% DS	31	No difference	Multivariate
de Feyter[15]‖	1988	179	88	>50% DS	32	LAD >right or LC	Multivariate
Fleck[16]*	1988	110	86	ΔMLCA >1 mm^2 (QCA)	58	No difference	Multivariate
Quigley[17]§	1989	114	88	>50% DS	32	No difference	Multivariate
Renkin[18]	1990	278	47**	>50% DS	—	No difference	Multivariate
Rupprecht[19]*	1990	676	70	>50% DS or decrease >50% of gain	29.2	No difference	Multivariate
Present study	1991	1,353	91	>50% DS	31	No difference	Univariate
				Relative loss	0.11 ± 0.21		Analysis of variance

*Excluded total occlusions; †multivessel dilatation; ‡multilesion dilatation; §for restenosis; ‖unstable angina; ¶review of patients with clinical recurrence; **angiography + exercise thallium scintigraphy.
Angio Fup = % of patients with angiographic follow-up; Dist = distal; DS = diameter stenosis; LAD = left anterior descending; LC = left circumflex; ΔMLCA = change in minimal luminal cross-sectional area; NHLBI = National Heart, Lung, and Blood Institute; pre = before; Prox = proximal; QCA = quantitative coronary angiographic method of analysis; RCA = right coronary artery; Symp = symptoms; VD = vessel disease.

tients with developing myocardial infarctions and significant left main disease were excluded from the study. PTCA was successful if the final diameter stenosis was <50% on visual inspection of the angiogram after PTCA. PTCA was considered complete when the guiding catheter was removed from the groin. When recurrence of chest pain during the hospital stay led to coronary reintervention, the film before reintervention was used as the follow-up angiogram. If a follow-up angiogram was obtained before 3 months and if no definite restenosis had occurred, the patient was asked to undergo another coronary angiogram at 6 months.

Figure 1 describes the flow chart of all 1,442 randomized patients. Of the 1,353 patients with successful PTCA, 1,234 patients had a follow-up angiogram after 6 months, or earlier when indicated for symptoms.

Percutaneous transluminal coronary angioplasty procedure and angiographic analysis: At the beginning of the procedure, all patients received a bolus of intravenous heparin (10,000 IU). After 2 hours, an additional infusion of heparin (5,000 IU/hour) was administered until the end of the procedure. Use of a calcium antagonist for 48 hours was permitted. Choice of balloon type, inflation duration and pressure was left to the discretion of the operator.

Three angiograms were obtained of each patient (1 immediately before and 1 immediately after PTCA, and 1 at follow-up). The angiograms were recorded in such a way that they were suitable for quantitative analysis by the coronary angiography analysis system. An example of an analysis is shown in Figure 2. To standardize the method of data acquisition and to ensure exact reproducibility of angiograms after PTCA

and at follow-up, measures were taken as described previously.[5,20]

All cineangiograms were quantitatively analyzed using the coronary angiography analysis system that has been validated and described in detail previously.[5,20] The absolute values of the stenosis diameter as well as the reference diameter are measured by computer using the known contrast-empty catheter diameter as a scal-
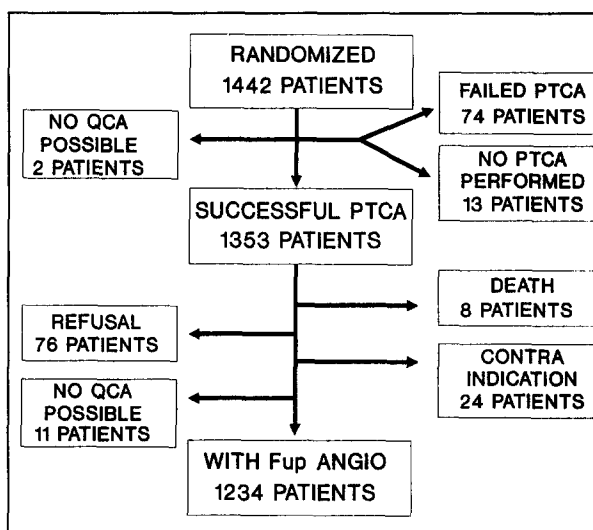

FIGURE 1. Flow chart of 1,442 randomized patients. In 74 patients, angioplasty procedure was unsuccessful, in 13, percutaneous transluminal coronary angioplasty (PTCA) was not performed, and in 2, quantitative analysis (QCA) was not possible. Angiographic follow-up (Fup ANGIO) was obtained in 1,234 patients (91%) after successful coronary angioplasty in 1,353.

ing device. For that purpose, the catheter tips were retained for accurate measurement with a micrometer. To achieve maximal vasodilation, either nitroglycerin (0.1 to 0.3 mg) or isosorbide dinitrate (1 to 3 mg) was administered for each coronary artery involved before and after PTCA, and at follow-up angiography. All contour positions of the catheter and the arterial segment were corrected for pincushion distortion introduced by the image intensifiers. Because the algorithm is not able to measure total occlusions and lesions with Thrombolysis in Myocardial Infarction-1 perfusion, a value of 0 mm was substituted for the minimal luminal diameter and 100% for the percent diameter stenosis. In these cases, the reference diameter after PTCA was substituted for the reference diameter before PTCA or at follow-up. For each dilated segment, the minimal luminal diameter and diameter stenosis before and after PTCA, and

at follow-up were taken as the mean value from multiple matched projections.[5]

Definition of coronary segments: Austen et al[21] divided the coronary tree in 15 different segments (Figure 3). Because dilatation of the distal vessel segments did not occur frequently, it was decided to regroup these distal segments. The right coronary artery was divided in 4 segments; segment 1 corresponded with the proximal, segment 2 with the middle, and segments 3 and 4 were taken together as the distal right coronary artery. The LAD was divided in 5 segments; segment 6 corresponded with the proximal LAD, segment 7 with the middle LAD, and segments 8, 9 and 10 were taken together as the distal LAD. The LC was divided in 5 segments; segment 11 corresponded with the proximal LC, segments 13 and 15 were taken together as the middle LC, and segments 12 and 14 were taken together as the distal LC.

Definition of restenosis: CATEGORICAL APPROACH: Many criteria have been proposed by the National Heart, Lung, and Blood Institute to assess restenosis. The most frequently used criterion by clinicians is that restenosis is present when the diameter stenosis is >50% at follow-up angiography.[22] This definition was used for our data.

CONTINUOUS APPROACH: In addition to this arbitrary categorical approach for restenosis, we wanted to use absolute changes in minimal luminal diameter adjusted for vessel size, which allows for comparison between vessels of different sizes and is a reflection of how the lesion behaves during and after PTCA.

Relative gain depicts the increase in minimal luminal diameter normalized for the reference diameter during PTCA (minimal luminal diameter [before PTCA − after PTCA]/reference diameter before PTCA). Relative loss depicts the decrease in minimal luminal diameter normalized for the reference diameter (minimal lu-
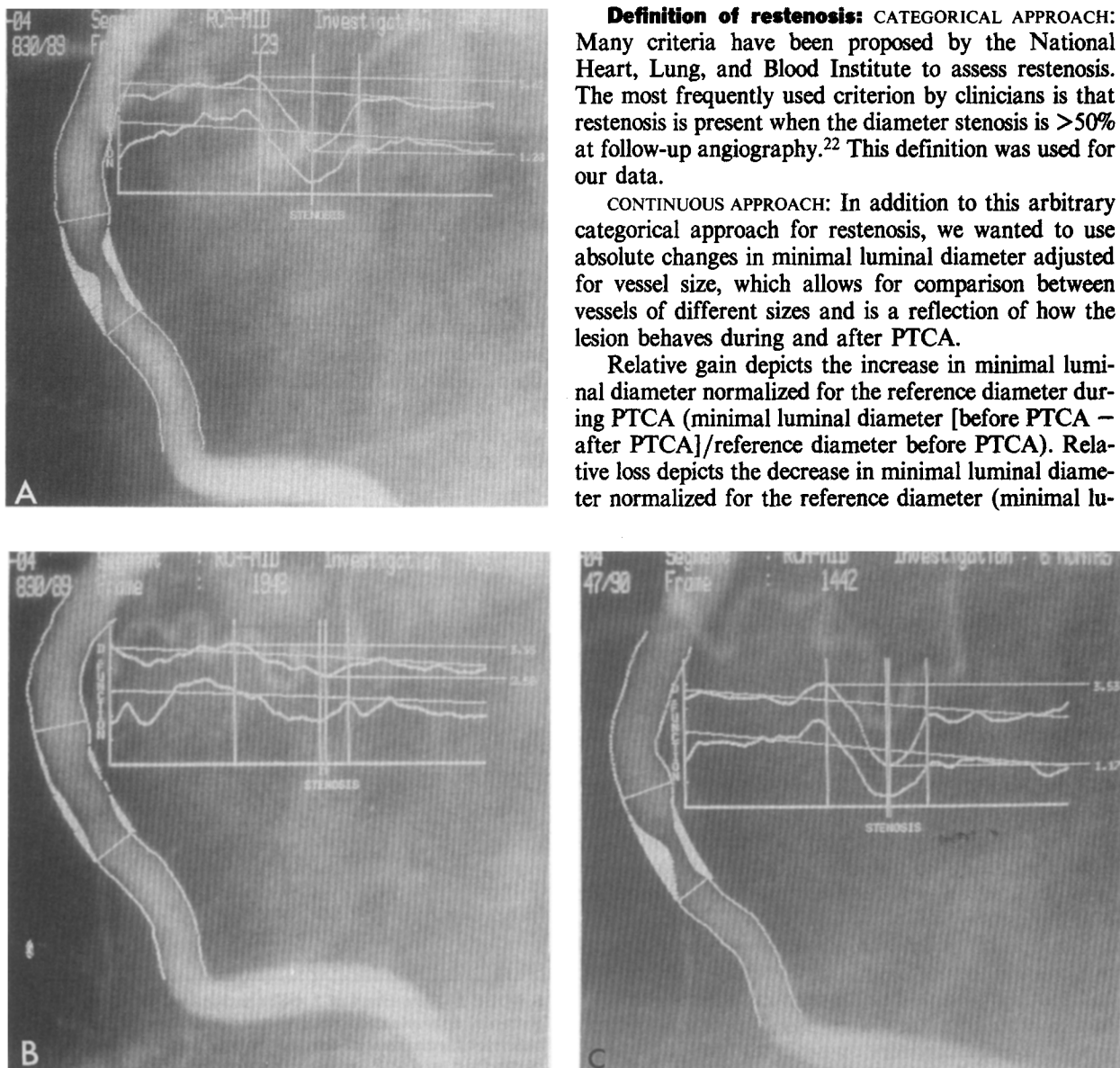

FIGURE 2. Single frame angiograms of same lesion of the right coronary artery before dilatation *(A)*, after dilatation *(B)* and at follow-up *(C)*. Arterial boundaries detected by system are shown on angiogram; *upper curve* represents diameter function curve. Minimal luminal diameter changes from 1.28 before to 2.58 mm after percutaneous transluminal coronary angioplasty. At follow-up 6 months later there is a decrease of minimal luminal diameter to 1.17 mm.

minal diameter [after PTCA − at follow-up]/reference diameter before PTCA) (Figure 4).

Data analysis: Data were analyzed using the bio-medical-designed program statistical software package (University of California Press, Berkeley, California, 1990). A chi-square test was used to assess differences in categorical variables. A 1-way analysis of variance was used to assess differences in continuous variables among the 3 major coronary arteries and the 9 different segments of the coronary tree. A p value <0.05 was considered indicative of a significant difference.

RESULTS

The mean time to follow-up angiography was 165 ± 42 days. In 1,234 patients, 1,452 lesions were successfully dilated (1.2 lesions/patient). In 74 patients, a totally occluded vessel segment was dilated. In 1,137 patients, 1-vessel dilatation was performed, 93 had 2-vessel dilatation, and 4 had all 3 vessels dilated. The majority of stenoses were located in the LAD (684 lesions) compared with 414 lesions in the right coronary artery and 354 in the LC.
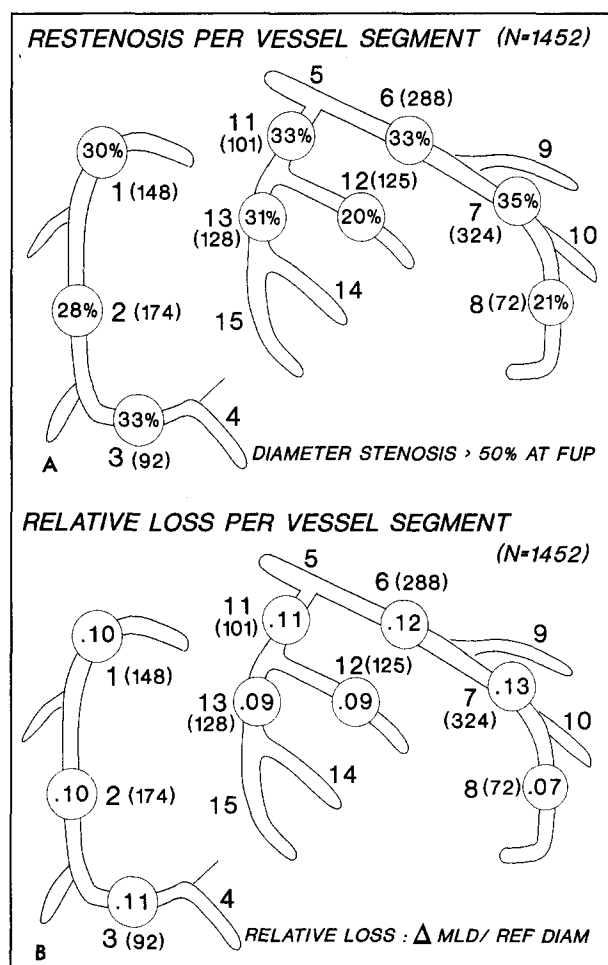
Table II lists the results of the quantitative measurements of the 1,452 lesions. The largest vessel was the right coronary artery, with an average reference diameter of 2.86 ± 0.55 mm. The LAD and LC had similar sizes; the average reference diameters were 2.54 ± 0.53 mm for the LAD, and 2.55 ± 0.50 mm for the LC (p <0.001). In addition, the average increases in minimal luminal diameter were 0.82 ± 0.37 mm in the right coronary artery, 0.71 ± 0.36 mm in the LAD, and 0.72 ± 0.35 mm in the LC. If these values were "normalized for the reference diameter" (relative gain), no significant differences were observed among either the 3 major coronary arteries (right coronary artery vs LAD vs LC; p = 0.44) or the different segments of the coronary tree (p = 0.77). During follow-up, the average losses in minimal luminal diameter were 0.26 ± 0.55 mm in the right coronary artery, 0.30 ± 0.48 mm in the LAD, and 0.25 ± 0.48 mm in the LC. If these values were normalized for the reference diameter (relative loss), no significant differences were observed among the 3 major coronary arteries (right coronary artery vs LAD vs LC; p = 0.13) or the different segments of the coronary tree (p = 0.19).

The restenosis rate, and relative gain and loss for the 3 major coronary arteries and the diverse vessel segments, using either the categorical or continuous approach, are listed in Table III. No significant difference in either approach was observed.

DISCUSSION

Several investigators have raised the question as to whether the dilated vessel constitutes a risk factor for the development of restenosis. They have reported conflicting results (Table I). The question is becoming even more relevant as new interventional techniques (such as stenting, atherectomy, laser photoablation and rotablation) have been "claimed" to be more effective than conventional balloon angioplasty in certain lesion types (long lesions and total occlusions), locations or vessels (right coronary artery, LAD, LC and bypass graft),[23]

FIGURE 3. Coronary tree divided in 15 different segments with restenosis rate (using >50% diameter stenosis as criterion) for each segment (A), and relative loss per coronary segment (B) shown in circles. Between brackets are numbers of lesions dilated for that segment. FUP = follow-up. ∆MLD/REF DIAM = decrease in minimal luminal diameter normalized for reference diameter.
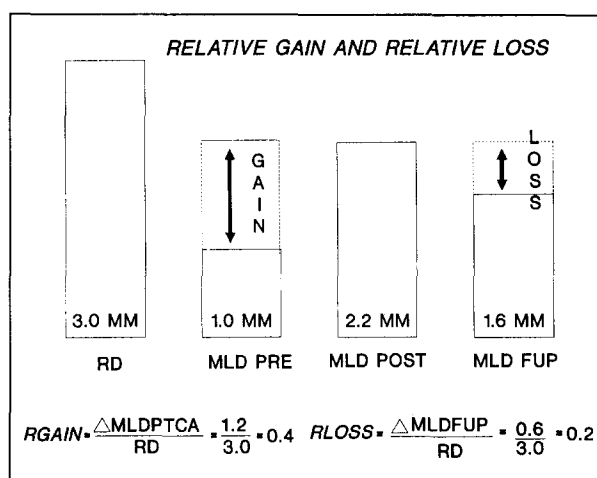

FIGURE 4. See text for explanation of relative gain (RGAIN) and relative loss (RLOSS). FUP = follow-up; MLD = minimal luminal diameter; POST = after; PRE = before; PTCA = percutaneous transluminal coronary angioplasty; RD = reference diameter.

although these new techniques have not yet succeeded in reducing restenosis rates.[24,25] Several explanations have been put forward to explain the increased risk for restenosis in the (proximal) LAD. Mata et al[8] believed that a high rate of "continuous success" needs an opti-mal selection of the balloon/artery ratio and optimal balloon pressure application. They suggested that anatomic or procedural factors were responsible for restenosis. Leimgruber et al[10] had 3 possible explanations. First, because they believed that the proximal LAD is

TABLE II Baseline Quantitative Angiographic Data per Vessel Segment Dilated

Coronary Artery	No.	Pre PTCA RD (mm)	Post PTCA RD (mm)	Follow-Up RD (mm)	Pre PTCA MLD (mm)	Post PTCA MLD (mm)	Follow-Up MLD (mm)
Total	1,452	2.63 ± 0.54	2.70 ± 0.52	2.70 ± 0.56	1.02 ± 0.38	1.77 ± 0.36	1.50 ± 0.57
Right	414	2.86 ± 0.55	2.93 ± 0.52	2.97 ± 0.58	1.08 ± 0.41	1.91 ± 0.37	1.65 ± 0.65
Proximal	148	2.99 ± 0.55	3.05 ± 0.51	3.07 ± 0.55	1.11 ± 0.45	1.96 ± 0.39	1.69 ± 0.63
Middle	174	2.82 ± 0.50	2.90 ± 0.50	2.94 ± 0.59	1.08 ± 0.41	1.91 ± 0.34	1.66 ± 0.65
Distal	92	2.71 ± 0.59	2.81 ± 0.56	2.85 ± 0.57	1.02 ± 0.35	1.83 ± 0.40	1.57 ± 0.66
LAD	684	2.54 ± 0.53	2.59 ± 0.49	2.58 ± 0.53	1.01 ± 0.36	1.72 ± 0.35	1.42 ± 0.53
Proximal	288	2.73 ± 0.52	2.78 ± 0.48	2.76 ± 0.53	1.08 ± 0.35	1.83 ± 0.35	1.53 ± 0.55
Middle	324	2.48 ± 0.47	2.52 ± 0.43	2.52 ± 0.47	0.97 ± 0.36	1.68 ± 0.32	1.35 ± 0.51
Distal	72	2.08 ± 0.44	2.14 ± 0.44	2.13 ± 0.42	0.87 ± 0.35	1.43 ± 0.29	1.29 ± 0.37
LC	354	2.55 ± 0.50	2.62 ± 0.46	2.61 ± 0.48	1.01 ± 0.36	1.73 ± 0.34	1.48 ± 0.51
Proximal	101	2.73 ± 0.47	2.75 ± 0.43	2.74 ± 0.44	1.06 ± 0.42	1.82 ± 0.32	1.52 ± 0.50
Middle	125	2.55 ± 0.50	2.64 ± 0.45	2.61 ± 0.50	1.00 ± 0.34	1.75 ± 0.32	1.52 ± 0.53
Distal	128	2.41 ± 0.49	2.50 ± 0.46	2.52 ± 0.48	0.98 ± 0.34	1.63 ± 0.34	1.41 ± 0.49

Values are means ± standard deviation.
LAD = left anterior descending; LC = left circumflex; MLD = minimal luminal diameter; Post = after; Pre = before; PTCA = percutaneous transluminal coronary angioplasty; RD = reference diameter.

TABLE III Restenosis Rate per Segment Using the Categorical Definition of > 50% DS at Follow-Up, and the Continuous Approach with Relative Gain and Loss

		DS (%) at Follow-Up > 50%			
	No.	Yes	No	Relative Gain	Relative Loss
Total	1452	444 (31)	1008 (69)	0.29 ± 0.16	0.11 ± 0.21
Right	414	123 (30)	289 (70)	0.30 ± 0.15	0.10 ± 0.22
Proximal	148	45 (30)	103 (70)	0.29 ± 0.15	0.10 ± 0.21
Middle	174	48 (28)	126 (72)	0.30 ± 0.15	0.10 ± 0.22
Distal	92	30 (33)	62 (67)	0.31 ± 0.15	0.11 ± 0.26
LAD	684	224 (33)	457 (67)	0.29 ± 0.17	0.12 ± 0.20
Proximal	288	95 (33)	193 (67)	0.29 ± 0.17	0.12 ± 0.19
Middle	324	114 (35)	210 (65)	0.29 ± 0.17	0.13 ± 0.21
Distal	72	15 (21)	57 (79)	0.27 ± 0.19	0.07 ± 0.15
LC	354	97 (28)	255 (72)	0.29 ± 0.16	0.11 ± 0.21
Proximal	101	33 (33)	68 (67)	0.29 ± 0.16	0.11 ± 0.18
Middle	125	25 (20)	100 (80)	0.30 ± 0.15	0.09 ± 0.21
Distal	128	40 (31)	88 (69)	0.28 ± 0.17	0.09 ± 0.21
p Value (right vs LAD vs LC)		0.22		0.44	0.13
(9 segments)		0.06		0.77	0.19

Values are means ± standard deviation.
Abbreviations as in Table I.

TABLE IV Relative Gain and Loss per Reference Diameter Group

						DS (%) at Follow-Up > 50%		
RD (mm)	No.	Absolute Gain (mm)	Relative Gain	Absolute Loss (mm)	Relative Loss	Yes	No	BAR
> 4.0 mm	18	0.72 ± 0.55	0.17 ± 0.13	0.13 ± 0.46	0.03 ± 0.10	6 (33)	12 (67)	0.77
3.5 to 4.0 mm	81	0.87 ± 0.47	0.24 ± 0.13	0.10 ± 0.50	0.03 ± 0.13	23 (28)	58 (71)	0.89
3.0 to 3.5 mm	222	0.83 ± 0.42	0.26 ± 0.13	0.33 ± 0.54	0.10 ± 0.17	71 (32)	151 (68)	0.97
2.5 to 3.0 mm	507	0.76 ± 0.40	0.28 ± 0.15	0.28 ± 0.52	0.10 ± 0.19	153 (30)	354 (70)	1.07
2.0 to 2.5 mm	454	0.72 ± 0.40	0.32 ± 0.17	0.28 ± 0.51	0.12 ± 0.23	148 (33)	306 (67)	1.20
< 2.0 mm	170	0.61 ± 0.34	0.34 ± 0.20	0.27 ± 0.46	0.15 ± 0.26	44 (26)	126 (74)	1.39
Analysis of variance		< 0.001	< 0.001	< 0.02	< 0.001	NS		

Values are means ± standard deviation.
BAR = balloon-artery ratio (size of the balloon according to manufacturer divided by the reference diameter before percutaneous transluminal coronary angioplasty); DS = diameter stenosis; NS = not significant; RD = reference diameter.

most often the largest artery, the 3.0 mm diameter balloons most frequently used at that time could have been undersized for the LAD and oversized for the right coronary artery and LC. This resulted in increased diameter stenosis after PTCA, which seems to be associated with a higher risk for restenosis. Second, a dilatation of the proximal LAD often involves the origin of the vessel and vessel branch points, and this factor also appears to be associated with an increased risk of restenosis. Third, the proximal LAD is well-recognized to develop "localized stenosis." Whether the same underlying mechanisms may predispose a patient to recurrence of lesions after angioplasty is unknown but well-conceivable.

Because balloon/artery mismatch was not identified as a predictor for restenosis in a group of patients with multilesion coronary angioplasty, Vandormael et al[13] suggested that the different anatomic and structural features of the proximal segment of the LAD compared with those of the proximal segment of the right coronary artery or LC may be responsible for the observation that dilatation of the proximal LAD is an independent risk factor for restenosis.

According to Califf et al,[3] 1 of the methodologic caveats for an increased rate of restenosis in the proximal LAD was that an ischemic response to exercise testing was more likely to be seen with proximal LAD lesions, thereby increasing the chance of preferential detection unless angiographic follow-up was complete. Also, a larger diameter of this vessel may have increased the risk that a satisfactory initial result was not achieved in earlier series, especially before the recent development of larger balloons to approach large vessels.

In the present study, no significant difference in the restenosis rate was found among the 3 major coronary arteries (p = 0.22) or the 9 coronary artery segments (p = 0.06) selected for the purpose of analysis. Our results contradict the earlier observations of Leimgruber and Califf and their coworkers that the proximal LAD is the largest vessel. In the present study, almost every segment of the right coronary artery has a larger diameter than the proximal LAD. An explanation for this discrepancy may be the differences in patient populations; availability of different balloon sizes (with diameters <2.0 mm as compared with those in the early days of PTCA when only balloon sizes of 3.7 mm were available) for dilatation may have affected PTCA of the proximal LAD. Another argument put forth in the early years that there was a mismatch between balloon catheters and proximal LAD is no longer valid, because in the present study, all patients underwent PTCA between December 1987 and December 1989 so that in all cases matched balloons were available. The differences in restenosis rates reported by these investigators are probably more related to the biased and incomplete angiographic follow-ups of these studies. In contrast, the present study has a 91% angiographic follow-up rate, and so the biased selection of symptomatic versus asymptomatic patients is virtually ruled out.

Definition of restenosis: The definition of restenosis has been the subject of much debate.[4] Of the different restenosis criteria proposed, >50% diameter stenosis at follow-up angiography is the most frequently used

to assess restenosis, because physiologic measurements have shown that the threshold for chest pain is near a reduction of 50% of the lumen of a normal vessel.[22] This definition was applied to our data. However, earlier studies have shown that the reference diameter can be involved in the dilatation process so that the % diameter stenosis could underestimate the change in the severity of a stenosis after PTCA.[26] Furthermore, the 50% diameter stenosis criterion at follow-up reveals nothing about the way the lesion has behaved since the PTCA procedure. We have previously shown that a change ≥0.72 mm in minimal luminal diameter is an appropriate method to assess intimal hyperplasia after coronary PTCA.[5,20,27] However, this criterion was historically assessed in vessels with an average reference diameter of 3.7 mm.[5,20] Therefore, it should be applied to vessels of comparable reference diameter; it is unlikely to have a decrease ≥0.72 mm in coronary segments with a reference diameter of 2 mm, and a minimal luminal diameter of 1.4 mm. In other words, criteria based on the absolute change in minimal luminal diameter are limited because they make no attempt to relate the extent of the restenosis process to the size of the vessel. To circumvent this limitation it was proposed to use the change in minimal luminal diameter from after PTCA to follow-up, normalized for the reference diameter (relative loss). This sliding scale criterion that adjusts for vessel size allows for regional assessment of the extent of the restenosis phenomenon in the entire coronary tree. No difference in relative loss among the 3 major coronary arteries (p = 0.13) or the coronary segments could be observed (p = 0.19). Restenosis should thus be viewed as a ubiquitous phenomenon that is inducible to the same extent in every segment of the coronary tree. It must be emphasized that the relative gain (change in minimal luminal diameter from before to after PTCA, normalized for the reference diameter) and thus the stimulus for restenosis[28] were similar in every segment of the coronary tree.

Because the subdivision of the American Heart Association-coronary segments is somewhat arbitrary in that vessels of different diameters are grouped together, we reanalyzed the data by stratifying the lesions according to their reference diameters. Table IV lists the results. It appears that the larger the reference diameter is before PTCA, the smaller the relative loss is at follow-up; vice versa, the greatest value of relative loss is observed in the smaller vessels. This may be explained by oversizing of the balloon in these vessels. However, if the restenosis criterion of >50% diameter stenosis is used, then similar restenosis rates are found.

Potential limitation of the study: Our study population consisted mainly of patients with 1 dilatation site; 1,044 patients had 1 dilatation site, and 190 underwent dilatation of ≥2 sites. The high incidence of 1 dilatation site reflects the fact that the study population included in these 2 trials consisted predominantly of patients with 1-vessel disease, so that our findings may not be extrapolated to a population with multivessel disease. Nevertheless, in the subset of 93 patients with multivessel dilatation, the overall restenosis rate per lesion was also 31%. However, the relative gain and loss observed in

patients with 1- and 2-vessel dilatations differed statistically; a relative gain of 0.30 ± 0.16 was seen for 1-vessel dilatation versus 0.27 ± 0.16 for 2-vessel dilatation (p <0.04), and a relative loss of 0.12 ± 0.21 for 1-vessel dilatation versus 0.08 ± 0.20 for 2-vessel dilatation (p <0.02). Thus, in the population with 2-vessel dilatation, a reduced gain is associated with a reduced loss consistent with the concept that PTCA operators are less aggressive in their dilating strategy.

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