Clinical Implications of Late Proven Patency After Successful Coronary Angioplasty

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Background. The introduction of percutaneous transluminal coronary angioplasty (PTCA) has changed the pattern of intervention in coronary artery disease. However, the long-term results in patients undergoing successful, elective, native-vessel PTCA are not yet fully characterized. Because the healing and subsequent proliferative response after angioplasty are time related, it was the purpose of the present study to determine the long-term outcome in patients whose dilated arteries have been demonstrated to be patent 4–12 months after successful, uncomplicated PTCA.

Methods and Results. The patients were grouped on the basis of the 4–12-month catheterization into those whose vessels were angiographically “normal” or had luminal irregularities only at the PTCA sites (396 patients), those whose vessels also had luminal irregularities elsewhere with or without PTCA site luminal irregularities (680 patients), and those with significant obstructive disease (more than 50% diameter narrowing) at sites other than the PTCA sites (426 patients). Of 1,502 such patients, long-term follow-up was available in 1,491. At the time of the original angioplasty, the normal patients had a 1.8% incidence of multivessel disease; luminal irregularity patients, 9.4%; and obstructive disease patients, 58.7%. At angiographic restudy, 16.4% of the obstructive disease patients continued to have multivessel disease. The patients were followed for the events of death, myocardial infarction, coronary surgery, and repeat PTCA. The 6-year survival rate was 95%; cardiac survival, 96%; and freedom from all events, 65%. The strongest correlate of events during follow-up was the angiographic status of the undilated segments. At 6 years, freedom from cardiac events was noted in 77% of the normal group, 61% of the luminal irregularity group, and 55% of the obstructive disease group. Diabetes and hypertension were also independent correlates of events.

Conclusions. Results from the present study show that associated disease in undilated segments is a strong predictor of late events in patients after successful, uncomplicated, restenosis-free PTCA. However, the need for further revascularization was frequent even in patients without obstructive disease. Completeness of revascularization is appropriate when possible, and limiting progression of coronary disease at sites remote from those dilated should improve on these late results. (Circulation 1991;84:572–582)

Since the introduction of percutaneous transluminal coronary angioplasty (PTCA) in 1977, much has been learned about the procedure, including the primary success rate, the dangers of the acute complications of myocardial infarction, the need for surgical revascularization, and the possibility of death. The incidence of restenosis and, to some extent, risk factors for restenosis have been defined. Recent studies have added to our knowledge of the long-term prognosis after successful PTCA.

Little is known about the long-term prognosis in patients who have successful PTCA, do not suffer complications, and are free from restenosis at angiographic restudy 4–12 months after PTCA, that is, patients with proven patency after the healing phase. PTCA is not a cure for coronary artery disease. Although late restenosis after the healing phase is rare, the process of atherogenesis in nondilated segments may be expected to continue. After successful PTCA with a good angiographic result and no
restenosis, some patients may be well revascularized, but others may have zones that were not revascularized. This therefore presents a situation in which the long-term results of PTCA may be assessed in patients who have little residual obstruction at the dilatation sites but variable degrees of atherosclerosis elsewhere in the coronary arteries. It was the purpose of the present study to assess the long-term prognoses of these patients with proven patency.

**Methods**

**Patient Population**

From June 1980 through December 1988, 7,561 patients without prior PTCA or coronary surgery had elective PTCA performed at the Emory University or Crawford W. Long Hospital. Included in this analysis were patients who had the procedure performed electively for stable or unstable angina pectoris or after several days of stabilization following acute myocardial infarction. Those who had the procedure performed in the setting of an acute evolving myocardial infarction or after cardiopulmonary resuscitation for cardiac arrest were not included in this study population. Of the total population, 6,925 patients had an angiographically successful procedure and did not suffer complications of a Q wave myocardial infarction, need for in-hospital coronary surgery, or death. Patients returned for restudy after PTCA either to determine whether restenosis has occurred or because of recurrent symptoms. From this population of initially successful patients, 3,056 patients had an angiographic restudy (44%). There were 1,533 patients with restenosis at one or more sites and 1,523 patients with angiographically documented patency at all sites. Of these 1,523 patients, 21 had been enrolled in the Emory Angioplasty Surgery Trial and were excluded from further study. The remaining 1,502 patients who met the criteria for successful PTCA (i.e., did not suffer complications of Q wave myocardial infarction or coronary surgery), were discharged alive, and were free of restenosis at all dilated sites when they returned for a first angiographic restudy 4–12 months after PTCA formed the population for this study.

**Definitions**

One-vessel disease was considered 50% or greater diameter luminal narrowing in the left anterior descending coronary, left circumflex, or right coronary artery or a major branch or branches. Multivessel disease was considered the presence of 50% or greater diameter luminal narrowing in more than one of these major epicardial vessel systems. Angiographically successful PTCA was when all lesions attempted improved more than 20% and were dilated to less than 50% residual diameter stenosis. Complete revascularization was improvement of more than 20% and dilatation to less than 50% residual diameter stenosis of all major obstructive lesions.

Restenosis was recurrent narrowing to more than 50% at any site dilated.

**Angiographic restudy groups.** The angiographic restudy groups were defined according to the status of the nondilated sites. In each group, there may be less than 50% diameter narrowing of the dilated sites. Groups were categorized as “normal” (nondilated sites showed no visually apparent luminal irregularities), “luminal narrowing” (one or more nondilated sites had luminal narrowing of less than 50% obstruction), and “obstructive disease” (one or more nondilated sites had obstructive disease with more than 50% diameter narrowing).

**Data Collection**

Baseline demographic, clinical, angiographic, and procedural data, including complications, were recorded prospectively by physicians on standardized forms and entered into a computerized data base. All data are audited for completeness and consistence by nurse auditors. The data entry programs screen for out-of-range and inconsistent values. The pre-PTCA, post-PTCA, and restudy angiograms were measured with digital electronic calipers (Sandhill Scientific Inc., Littleton, Colo.) by experienced angiographers other than the primary operator. The narrowing of each coronary artery lesion was expressed as the percent diameter narrowing of the abnormal segment compared with the normal adjacent arterial regions. The recorded diameter stenosis was the mean value determined in two near-orthogonal views.

**PTCA Technique and Angiographic Restudy**

All PTCA procedures were performed using standard techniques that have previously been described. All patients received 325 mg aspirin, and most received a calcium channel–blocking agent (10 mg nifedipine t.i.d. or 30–60 mg diltiazem q.i.d.) orally before the PTCA procedure unless a prior history of an adverse or hypersensitivity reaction was present. Before attempted balloon dilatation, 5–10 mg diazepam, 0.6–1.0 mg atropine, and 10,000–15,000 units heparin were given intravenously.

Restudy angiography after PTCA was performed under the guidance of the primary PTCA operator. While the entire coronary tree was visualized, special attention was directed at the original dilatation sites. Assessment of the severity of obstruction of these sites was specifically addressed and recorded.

**Patient Follow-up**

Follow-up information was obtained by telephone interviews of the patients or their referring physicians. Follow-up information included occurrence of myocardial infarction since the initial PTCA, subsequent need for an additional revascularization procedure (PTCA or coronary artery bypass graft surgery [CABG]), or death (cardiac or noncardiac). Follow-up telephone calls were made by specially trained interviewers. The interviewers were trained to grade subjective questions such as severity of
Statistical Analyses

Differences in categorical variables were analyzed by $\chi^2$, and differences in continuous variables were analyzed by a one-way analysis of variance. The patients were divided by angiographic restudy group. Clinical, angiographic, and procedural characteristics of each group were determined. Patient survival, cardiac survival, and event-free survival were determined by the Kaplan-Meier method, and probability was expressed as mean±SEE. Overall survival and event-free survival analyses were performed on the total population as well as on the subgroups. When calculating cardiac death, patients dying of noncardiac causes were censored at the time of their death. End points analyzed included patient and cardiac survival; survival without cardiac death or myocardial infarction; survival without cardiac death, myocardial infarction, or need for CABG surgery; and survival without cardiac death, myocardial infarction, or need for CABG surgery or repeat PTCA (coronary events). Comparisons of total and event-free survival were made using the Mantel-Cox method. Correlates of late events were determined by the Cox proportional hazards model. For Cox model analyses, continuous covariates were not broken into groups. All statistical analyses were performed with BMDP statistical software (Los Angeles).

Results

Baseline Data at Time of PTCA

The present study concerns 1,502 patients who underwent successful, uncomplicated dilatation of all PTCA sites and remained free from restenosis when studied angiographically 4–12 months later. The clinical characteristics of these patients are presented in Table 1. Patients are divided into those with luminal irregularities confined to the previous site or sites of dilatation (normal), those with luminal irregularities at other sites, and those with obstructive coronary disease at other sites. Mean patient age increased from 54 years in the normal group to 58 years in the group with obstructive disease ($p<0.0001$). Similarly, the percentage of patients more than 65 years old also increased with age ($p=0.0001$). Approximately 75% of the patients were male, with no difference among groups. Frequency of diabetes increased from 6.6% in the normal group to 12.0% in the patients with obstructive disease ($p=0.014$). Hypertension was noted in approximately 40%, with a trend to greater hypertension in the patients with more significant disease. The prevalence of a prior myocardial infarction increased from 25% in normal patients to 42% in those with obstructive disease ($p<0.0001$). Left ventricular hypertrophy was uncommon, although it was seen more often in the obstructive disease group. Few patients were asymptomatic. New York Heart Association functional class III or IV angina was noted frequently and increased in prevalence from 42.7% in normal patients to 55.0% in patients with obstructive disease. Serum cholesterol was mildly elevated but did not vary among the groups.

<table>
<thead>
<tr>
<th>TABLE 1. Baseline Clinical Characteristics</th>
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<tbody>
<tr>
<td>Total</td>
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<tr>
<td>-------</td>
</tr>
<tr>
<td>Patients (n)</td>
</tr>
<tr>
<td>Age (mean±SD years)</td>
</tr>
<tr>
<td>Patients ≥65 years old (n)</td>
</tr>
<tr>
<td>Men (n)</td>
</tr>
<tr>
<td>Current smoker (n)</td>
</tr>
<tr>
<td>Diabetes mellitus (n)</td>
</tr>
<tr>
<td>Hypertension (n)</td>
</tr>
<tr>
<td>Prior myocardial infarction (n)</td>
</tr>
<tr>
<td>Left ventricular hypertrophy (n)</td>
</tr>
<tr>
<td>NYHA angina class (n)</td>
</tr>
<tr>
<td>Asymptomatic</td>
</tr>
<tr>
<td>Class I or II</td>
</tr>
<tr>
<td>Class III or IV</td>
</tr>
<tr>
<td>Serum cholesterol (mg/dl)</td>
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</table>

NYHA, New York Heart Association. Values in parentheses represent percentages.
Baseline angiographic and procedural data are presented in Table 2. Multivessel disease at the time of the original procedure correlated strongly with the presence of obstructive disease at restudy. Few of the patients with multivessel disease were in the angiographically normal group at restudy. Just more than half of the patients with obstructive disease at follow-up originally had multivessel disease. The majority of the patients had left anterior descending coronary artery disease. Multisite dilatations were performed in a minority of cases. Left ventricular function was generally normal but lower in the group with obstructive disease. The mean pre-PTCA percent diameter stenosis was approximately 73% for the first lesion dilated and slightly less for subsequent lesions. There was no difference between groups in the severity of the original stenoses. The mean post-PTCA percent diameter stenosis was slightly higher for the group presenting later with obstructive disease (25%) compared with the other two groups (23%; p = 0.019). Similar trends were noted for subsequent sites. Incomplete revascularization was a major cause of obstructive disease at follow-up, with only 43.7% of patients with obstructive disease originally having had complete revascularization.

**Restudy Clinical and Angiographic Data**

Clinical and angiographic status at arteriographic restudy are presented in Table 3. Mean time to arteriographic restudy was just less than 7 months after PTCA. At that time, just more than 20% of the patients were asymptomatic, whereas a minority of the patients had severe angina, far fewer than before PTCA. The patients were selected for absence of restenosis, so less severe angina would be anticipated. Nevertheless, the percentage of patients with severe angina increased from 13.8% in the normal group to 30.3% in the group with obstructive disease (p = 0.0005). The percentage of current smokers declined from more than 20% before angioplasty to just less than 10% at follow-up. There was no difference among groups. The residual diameter narrowing of the dilated sites was 27% for the first site dilated and slightly higher in the luminal irregularity and obstructive disease groups (p = 0.012). Similar data were noted for the second and third sites. By definition, multivessel disease was confined to the obstructive disease group and was present in 16.4%. Left ventricular function remained well preserved, with slightly lower ejection fraction and more patients with abnormal ejection fractions in the obstructive disease group.

**Long-term Outcome**

A principal concern was how would these patients do over the next several years. Evaluation of angina at the time of follow-up was available in 1,348 patients at 40±21 months after the arteriographic restudy (Table 4). Angina was present in 30.2%, and it was not related to the number of vessels originally diseased or to the angiographic restudy group.

Six-year follow-up for the entire population, with follow-up from the time of restudy arteriography, is presented in Figure 1. The four curves show cardiac death; cardiac death or nonfatal myocardial infarction; cardiac death, nonfatal myocardial infarction, or CABG; and cardiac death, nonfatal myocardial infarction, CABG, or PTCA (coronary events). The
Correlates of cardiac death, using the variables in Tables 1–3 (for diameter stenosis before PTCA, after PTCA, and at restudy, only the first lesion value was tested as a covariate), are presented in Table 5. The univariate and multivariate correlates of cardiac survival are age, diabetes mellitus, and the pre-PTCA division into one-vessel versus multivessel disease. Of interest, the ejection fraction was not a correlate, perhaps because the distribution of ejection fractions in this population was heavily weighted to normal. Patients with diabetes had the lowest survival (82% at 6 years), but this represented a relatively small percentage of the total population (Table 1). The Cox model analysis was used to predict cardiac survival in patient profiles representing relative extremes of the PTCA population (Figure 2). A 50-year-old patient with one-vessel disease and no diabetes was a fairly typical patient profile for angioplasty. If this patient is free of restenosis at 6-month restudy, than cardiac survival of 98% at 6 years would be expected. A 70-year-old patient with multivessel disease and diabetes represents a more seriously diseased patient for angioplasty and has the corresponding lower cardiac survival of 70% at 6 years, even in the absence of restenosis.

Correlates of coronary events, using the variables in Tables 1–3 (for diameter stenosis before PTCA, after PTCA, and at restudy, only the first lesion value was tested as a covariate), are presented in Table 6. The univariate correlates of events are the degree of angiographic obstruction as indicated by the angiographic restudy group, diabetes mellitus, hypertension, and the pre-PTCA division into one-vessel versus multivessel disease. All except the original one-vessel/multivessel division remained correlates by multivariate analysis.
The strongest correlate was the restudy angiographic group. Of interest, although diabetes and hypertension were correlates, age, ejection fraction, serum cholesterol level, and cigarette smoking at entry or time of restudy were not correlates.

In Figure 3, coronary events are examined in the three restudy angiographic groups. The fewest events occurred in the normal patients, and the most occurred in the obstructive disease patients. The normal patients had no events during the first 3 months. The patients with obstructive disease would be expected to have a large number of revascularization procedures after angiographic restudy. Of these 426 patients, 32 (7.5%) had angioplasty and eight (1.9%) had coronary surgery within the initial hospitalization or within 10 days of the angiographic restudy. Thereafter, these curves reveal continuing events over time without evidence of leveling off at any time during the 6-year period. At 6 years, the rate of actuarial freedom from cardiac events was 77% in the normal group, 61% in the luminal irregularity group, and 55% in the obstructive disease group (p<0.0001).

The follow-up events include 184 angioplasty procedures, of which 54 (29.3%) were to previously dilated sites. In the normal group, there were 32 angioplasties with eight (25.0%) at previously dilated sites; in the luminal irregularity group, there were 72 angioplasties with 20 (27.8%) at previously dilated sites;

**Figure 1.** Plots of 6-year freedom from (FF) events in 1,491 patients who had elective percutaneous transluminal coronary angioplasty (PTCA) and proven patency at all sites dilated. The four curves represent cardiac survival; FF death or myocardial infarction (MI); FF death, MI, or coronary artery bypass graft surgery (CABG); and FF death, MI, CABG, or PTCA.

**Table 5.** Correlates of Cardiac Death During Follow-up

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>6-Year survival</th>
<th>Univariate correlates</th>
<th>Multivariate correlates</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;60</td>
<td></td>
<td></td>
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</tbody>
</table>
| ≥60         | 0.97±0.01       | 12.2                  | 12.2                   | <0.001
| 0.93±0.02   | 0.0005          | 0.0580                |                        |
| Diabetes    | 0.97±0.01       | 9.5                   | 8.4                    | 0.004
| Absent      | 0.82±0.07       | 0.0021                | 1.2061                 |                  |
| Present     | 0.91±0.03       | 3.6                   | 0.059                  | 0.5475                |
| Pre-PTCA vessels diseased | 0.97±0.01 | 4.8                   | 0.029                  |                       |
| One-vessel disease | 0.91±0.03 | 3.6                   | 0.059                  | 0.5475                |
| Multivessel disease | 0.97±0.01 | 4.8                   | 0.029                  |                       |

PTCA, percutaneous transluminal coronary angioplasty.
and in the obstructive disease group, there were 80 angioplasties with 26 (32.5%) at previously dilated sites.

In Figure 4, three patient profiles are considered based on the Cox model analysis presented in Table 3. The curves represent the expected freedom from events derived from the model, not Kaplan-Meier curves. The patient profiles are angiographically normal without hypertension and diabetes, angiographically normal but with hypertension and diabetes, and obstructive disease with hypertension and diabetes. Note that the scale on the y axis is different from that in Figures 1 and 2 because patients with obstructive disease, hypertension, and diabetes have a low expected freedom from events rate. The expected freedom from events rate was 81% in the normal

**FIGURE 2. Plots of predicted 6-year cardiac survival in two patient profiles defined by Cox model. Profiles are of a 50-year-old patient with one-vessel disease and no diabetes and a 70-year-old patient with multivessel disease and diabetes.**

<table>
<thead>
<tr>
<th>Age 50, 1 Vessel Disease, No Diabetes</th>
<th>50 Years Old, 1 Vessel Disease, No Diabetes</th>
<th>Survival</th>
<th>1</th>
<th>1.00</th>
<th>1.00</th>
<th>0.99</th>
<th>0.99</th>
<th>0.98</th>
<th>0.98</th>
<th>0.98</th>
<th>0.98</th>
<th>0.98</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 Years Old, Multivessel Disease, Diabetes</td>
<td>Survival</td>
<td>1</td>
<td>0.97</td>
<td>0.93</td>
<td>0.93</td>
<td>0.88</td>
<td>0.86</td>
<td>0.79</td>
<td>0.77</td>
<td>0.68</td>
<td>0.65</td>
<td>0.65</td>
</tr>
</tbody>
</table>

**TABLE 6. Correlates of Events During Follow-up**

<table>
<thead>
<tr>
<th>Angiographic group</th>
<th>6-Year freedom from events</th>
<th>Univariate correlates</th>
<th>Multivariate correlates</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0.77±0.04</td>
<td>52</td>
<td>&lt;0.0001</td>
<td>52</td>
</tr>
<tr>
<td>Luminal irregularities</td>
<td>0.61±0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obstructive disease</td>
<td>0.55±0.04</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>0.66±0.03</td>
<td>15</td>
<td>0.0001</td>
<td>12</td>
</tr>
<tr>
<td>Present</td>
<td>0.42±0.09</td>
<td></td>
<td></td>
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<tr>
<td>Hypertension</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>0.69±0.03</td>
<td>9.5</td>
<td>0.0021</td>
<td>5.7</td>
</tr>
<tr>
<td>Present</td>
<td>0.58±0.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-PTCA vessels diseased</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-vessel disease</td>
<td>0.67±0.03</td>
<td>21</td>
<td>&lt;0.0001</td>
<td>NS</td>
</tr>
<tr>
<td>Multivessel disease</td>
<td>0.53±0.06</td>
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</table>

PTCA, percutaneous transluminal coronary angioplasty.
Cardiovascular events include death, myocardial infarction, coronary artery bypass surgery, and repeat PTCA.
patients without diabetes or hypertension, 61% in the normal patients with diabetes and hypertension, and 22% in the patients with obstructive disease, diabetes, and hypertension.

Discussion

In the present study, we examined the late clinical outcomes in 1,491 of 1,502 patients who underwent elective PTCA and were proven to have all sites patent at repeat angiography 4–12 months after the original procedure. The present study has shown that survival is excellent to 6 years and that the incidence of acute myocardial infarction is relatively low. However, repeat revascularization procedures, mostly angioplasty, were performed frequently. If patients without angiographic restudy were included, these event rates might be lower and the results more favorable because the most stable patients may be less likely to have an angiographic restudy. Although events are most common if there is remaining obstructive disease, events continue to occur even in patients with angiographic disease limited to luminal irregularities at the PTCA site, a group labeled “normal.” Of note, only 28% had obstructive disease at angiographic restudy. It must be noted that angiographically normal does not necessarily mean free of disease. In addition to remaining luminal irregularity at the original PTCA site, there may be diffuse atherosclerosis without focal narrowing.

Prognosis After PTCA and Completeness of Revascularization

Multiple studies have evaluated the long-term prognosis after PTCA, although in all of these studies there were both patients with and those without restenosis. Late follow-up of the first patients undergoing PTCA in Zurich in the 1970s showed good survival. Five-year follow-up after PTCA has been reported in a study of a 1-year cohort of patients from Emory. The 5-year cardiac survival was 98%; myocardial infarction-free survival was 92%; and freedom from death, myocardial infarction, or CABG was 79%. Although the patient population was quite different, these figures are similar to those in the present study. There was also continuing incidence of the need for coronary surgery, including those with clinically successful PTCA and one-vessel disease. One-year follow-up of the 1985–1986 National Heart, Lung, and Blood Institute’s Angioplasty Registry revealed a mortality of 3.2%, infarction rate of 7.2%, and coronary surgery rate of 13.2%. In the patients who had successful angioplasty, follow-up events were death (1.9%), myocardial infarction (2.6%), CABG (6.4%), and repeat angioplasty (20.7%). A Duke University study emphasized the good survival of medically treated patients from the early 1980s judged to be PTCA candidates. The 5-year survival was 97%, and the myocardial infarction-free survival was 85%. Improved prognosis with
complete revascularization has been emphasized previously. In particular, Samson et al.\textsuperscript{18} showed that there is a higher rate of cardiovascular events in patients who are incompletely revascularized compared with patients who are completely revascularized by PTCA. Samson et al. also provided an extensive literature review, revealing that although there is some controversy, most larger studies showed that events are more common in incompletely revascularized patients. Similar data are available for patients after coronary surgery. Jones et al.\textsuperscript{19} have shown that patients with three-vessel disease who have complete revascularization have improved survival and less recurrent angina and return to work more often than do those with incomplete revascularization.

**Progression of Disease**

Although progression of disease was not directly documented in the present study, it appears to be the most likely explanation for at least some of the cardiovascular events. This is most clearly relevant in the patients without remaining obstructive disease. In patients with established disease, progression has been studied arteriographically, occurs at a variable rate, and appears to be accelerated by hyperlipidemia.\textsuperscript{20–28} Variability in the observed rate of progression will also depend on the timing of restudy and on the methods used to assess the arteriogram. Brown et al.\textsuperscript{29} studied progression and regression in patients with elevated apolipoprotein B randomized to conventional versus aggressive therapy over 2.5 years. In the controls, 46% suffered progression, whereas 11% had regression. In the treated patients, 23% had progression, and 35% had regression. In the controls, 19% had events (death, myocardial infarction, or need for revascularization) versus 5% in treated patients. This study linked progression of disease to clinical events.

What, then, do the results of the present study have to say about the role of PTCA, the importance of completeness of revascularization, and the importance of progression of disease? The present study differs from most PTCA follow-up studies in that it specifically investigates patients whose procedures were clinically successful and restenosis free. We note in the present study that death was rare but repeat procedures were relatively common. Events are most common in patients who had obstructive disease, and most of these patients did not have complete revascularizations. However, the fact that patients without obstructive disease also suffered cardiovascular events suggests that there is late restenosis, progression of disease elsewhere, or both. In this regard, fewer than 30% of the repeat angioplasties during follow-up in the present study were performed for restenosis at a previously dilated site.
In addition, an angiographic follow-up study has shown a very low late restenosis rate of precisely located dilatation sites. Careful angiographic analysis showed late restenosis to occur in only four of 128 patients previously shown to be patent at all sites. These data suggest that late restenosis at previously patent sites can account for only some of the events noted here. Thus, there appears to be three mechanisms that explain late events: events related to obstructive disease that was not completely revascularized during the original procedure, events related to progression of disease, and late restenosis.

If relentless progression of disease is an underlying pathophysiological process, then revascularization is one therapeutic maneuver in the life-long management of the disease. This is true of the patients who are well revascularized as well as of those who could not be as well revascularized. Thus, all patients—not just those with remaining obstructive disease—may warrant aggressive risk factor intervention, at least concerning cigarette smoking, control of hypertension, and aggressive treatment of hyperlipidemia. Cessation of cigarette smoking has been shown in many studies to reduce the mortality and reinfection rates after acute myocardial infarction. Cigarette smoking is almost certainly of importance in promoting the development of atherosclerosis as well as having acute effects that may lead to myocardial infarction. Cigarette smoking is a difficult variable to quantify; it may be measured at only one point in time; and data collection may not be reliable. The incidence of smoking at the time of follow-up angiography was low, and more symptomatic patients may have been less likely to smoke; this may explain why cigarette smoking did not predict late events. The importance of hypertension and diabetes in the present study is certainly of interest. As noted, angiographically “normal” vessels may actually be diffusely narrowed by atherosclerosis. Thus, hypertension and diabetes may be markers for diffuse disease or risk factors for completely new lesions. That serum cholesterol failed to predict events is somewhat surprising. The present study is not likely to be as sensitive to the influence of cholesterol as would be a study specifically addressing this issue. A single, randomly drawn, total serum cholesterol measured at hospital admission during a period when the patient is most symptomatic from coronary disease may not accurately reflect serum lipid abnormalities.

Limitations

One limitation was that only 44% of patients were restudied. In addition, patients without restenosis may be restudied less frequently than patients with restenosis because they are less likely to have recurrent angina. Some patients were restudied routinely to determine if there was restenosis, and some patients were restudied because of recurrent angina. In patients who do not have restenosis but undergo angiography at 4–12 months, there may be more progression of disease or less complete original revascularization than in patients who are not restudied. Should this be the case, then there is a systematic bias that may make the event rates higher than in all patients free of restenosis (those restudied plus those not restudied). An extension of this is that observed event rates may depend on the rate of restudy. This potential bias was limited by considering patients according to their angiographic follow-up group. Within each group, event rates may more realistically reflect event rates in all patients free of restenosis. Nevertheless, these results can only be applied with caution to patients not undergoing restudy or to populations with markedly different indications for restudy.

Another limitation concerns the nature of data collection in clinical data bases. These data were collected by many people during a period of years, which is the only practical way to collect such data. This may be seen as being in contradistinction to a small, tightly focused prospective clinical trial. This problem was mitigated as much as possible in the present study through the use of careful auditing. The personnel conducting telephone follow-ups are specially trained. Deaths and revascularization procedures occurring at Emory University Hospital were captured in this study directly from the clinical data base as well as by telephone survey. Because death is a reliable end point and the majority of the revascularization procedures occurred at Emory, underreporting of events is most likely to be slight. Assessing acute myocardial infarction by telephone survey is more difficult. Overreporting and underreporting are both possible. Detailed data reported from clinical data bases must always be viewed in light of the serious limitations in data collection; the data may be viewed as expressing best approximations and differences among the study groups presented to understand what will happen after PTCA.

Conclusions

Results from the present study reveal that continuing coronary events occur after successful, uncomplicated, restenosis-free PTCA. Given the above successful, in patients who have had successful restenosis-free PTCA, events were much more common if significant obstructive disease remained. However, even in completely revascularized patients there were continuing events. Thus, complete revascularization remains a goal, although the clinical setting or technical limitations may make this impossible. Once the procedure is finished, risk factor intervention may limit progression of disease. In conclusion, concerned and careful medical care of PTCA successes is the appropriate goal.

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