Title

Predictors of outcome of percutaneous excimer laser coronary angioplasty of saphenous vein bypass graft lesions

Journal

The American Journal of Cardiology, 74(2)

ISSN

0002-9149

Authors

Bittl, John A
Sanborn, Timothy A
Yardley, David E
et al.

Publication Date

1994-07-01

DOI

10.1016/0002-9149(94)90087-6

Predictors of Outcome of Percutaneous Excimer Laser Coronary Angioplasty of Saphenous Vein Bypass Graft Lesions*

John A. Bittl, MD, Timothy A. Sanborn, MD, David E. Yardley, MD, James E. Tcheng, MD, Jeffrey M. Isner, MD, Saurabh K. Chokshi, MD, Bradley H. Strauss, MD, George S. Abela, MD, Paul D. Walter, MD, Mark Schmidhofer, MD, and John A. Power, MD, for the Percutaneous Excimer Laser Coronary Angioplasty Registry

A total of 495 patients underwent treatment with excimer laser angioplasty for 545 saphenous vein graft stenoses. Clinical success was achieved in 455 of 495 patients (92%), as indicated by ≤50% residual stenosis at every target lesion and no complication during hospitalization. At least 1 in-hospital complication occurred in 30 of 495 patients (6.1%): death (1.0%), bypass surgery (0.6%), and Q-wave (2.4%) or non–Q-wave (2.2%) myocardial infarction. Relative risk analysis showed that ostial lesions (n = 65) tended to have higher clinical success (success rate = 95%, adjusted odds ratio [OR] = 2.1 [95% confidence interval (CI) 0.62, 6.88]; p = 0.24) and lower complications (complication rate = 0%, OR = 0.10 [CI 0.01, 0.79]; p = 0.03) than lesions in the body of the vein graft. Lesions >10 mm (n = 131) had lower success (success rate = 84%, OR = 0.30 [CI 0.16, 0.56]; p = 0.001) and higher complications (complication rate = 12%, OR = 3.3 [CI 1.6, 6.6]; p = 0.004) than discrete lesions. Lesions in small vein grafts <3.0 mm (n = 76) tended to have increased success (success rate = 94%, OR = 1.55 [CI 0.70, 3.44]; p = 0.39) and lower complications (complication rate = 2.2%, OR = 0.31 [CI 0.10, 0.94]; p = 0.03). Thus, excimer laser–facilitated angioplasty has the most favorable outcome for discrete lesions located at the ostium of all grafts and in the body of smaller saphenous vein grafts. Comparison of excimer laser angioplasty with other treatments for these types of saphenous vein graft lesions is required to establish the clinical usefulness of excimer laser treatment.

(Am J Cardiol 1994;74:144–148)

From the Departments of Medicine of Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts; New York Hospital-Cornell Medical Center, New York, New York; St. Anthony's Medical Center, Rockford, Illinois; Duke University Medical Center, Durham, North Carolina; St. Elizabeth's Hospital and Tufts University, Boston, Massachusetts; Tampa General Hospital, Tampa, Florida; St. Michael's Hospital, University of Toronto, Ontario, Canada; New England Deaconess Hospital, Boston, Massachusetts; St. Francis Hospital, Pittsburgh, Pennsylvania; and Cardiology Associates, Methodist Hospital, Lubbock, Texas. Manuscript received September 1, 1993; revised manuscript received December 7, 1993 and accepted December 13.

Address for reprints: John A. Bittl, MD, Cardiovascular Division, Brigham and Women's Hospital, Boston, Massachusetts 02115.

*Presented in part at the meeting of the American College of Cardiology in Anaheim, California, on March 17, 1993.

Angioplasty of saphenous vein graft lesions remains a significant challenge. Embolization of thrombus or atheromatous material occurs in 2% to 17% of patients, and restenosis at the treated site appears in 50% to 80%.[1–4] Excimer laser coronary angioplasty was first reported as a potentially useful treatment for patients with saphenous vein graft lesions over 4 years ago.[5] Since then, several other studies have reported favorable results.[6–8] However, the influence of saphenous vein graft lesion morphology on the outcome of excimer laser angioplasty remains unknown. The purpose of this study was to test the hypothesis that the angiographic characteristics of saphenous vein lesions affect success and complication rates after excimer laser angioplasty.

METHODS

Patient enrollment: Between May 8, 1989, and February 28, 1993, a total of 495 patients had 545 lesions in saphenous vein grafts treated with excimer laser angioplasty in the Percutaneous Excimer Laser Coronary Angioplasty Registry (see Appendix). Patients were not considered for excimer laser angioplasty if they had a filling defect in the vein graft selected for treatment with excimer laser angioplasty, except in 8 cases reported elsewhere,[9] or if the lesion existed in the angulated anastomotic site. All patients were requested to return for 6-month angiographic follow-up. All patients gave informed consent to participate in the protocol, which was approved by both the Food and Drug Administration and the institutional review boards of the participating hospitals.

Excimer laser angioplasty: All patients were treated with the CVX-300™ excimer laser (Spectranetics Corporation, Colorado Springs, Colorado), using over-the-wire catheters with diameters of 1.4, 1.7, or 2.0 mm and techniques previously described.[8]

Definitions: *Distal embolization* was defined by filling defects distal to the treated graft, with or without evidence of "no-reflow." (Creatine kinase measurements were required only for patients with new electrocardiographic changes or ischemic chest pain lasting >30 minutes.) *Angiographic restenosis* was defined by the presence of >50% stenosis at the treated site. *Graft perforation* was defined by a persistent extravascular collection of contrast medium beyond the graft wall with a well-defined exit port. An *ostial lesion* was defined as a stenosis positioned within 2 mm of the origin of the graft. An *ulcerated lesion* was defined by the appearance of an abrupt face, scalloped edge, or irregular border.[10] *Lesion length* was measured with calipers, using catheter

TABLE I Description of 545 Stenoses

Eccentric (%)	283	(52)
Length >10 mm (%)	131	(24)
Restenosis (%)	87	(16)
Ulcerated (%)	82	(15)
Ostial (%)	65	(12)
Adjunctive balloon angioplasty (%)	496	(91)
Adjunctive directional atherectomy (%)	2	(0.4)
Adjunctive graft stenting (%)	0	(0.0)
Mean graft age (years)	8.0± 2.0	

TABLE II Complications

Complications in 495 patients (%)		
Death during hospitalization	5	(1.0)
CABG during hospitalization	3	(0.6)
Q-wave MI	12	(2.4)
Non-Q-wave MI	11	(2.2)
Complications for 545 stenoses (%)		
Dissection	48	(8.8)
Abrupt closure	22	(4.0)
Embolization	18	(3.3)
Perforation (minor contrast extravasation only)	7	(1.3)
Perforation with clinical complication	0	(0.0)

CABG = coronary artery bypass graft surgery; MI = myocardial infarction.

calibration to account for magnification, and defined as the distance from the proximal to the distal shoulder spanning ≥50% stenosis in a nonforeshortened projection. *Graft diameter* was measured with calipers, using the guide catheter centered in the frame as calibration reference.

Statistical analysis: Logistic regression analysis identified predictors of clinical success or major complication from the following variables: graft size, lesion length, or lesion morphology. Odds ratios were calculated to give the likelihood that patients with a given variable had increased or decreased likelihood of an outcome, as compared with all other patients without the variable.[11] Adjusted odds ratios with 95% confidence intervals for clinical success and restenosis were calculated according to the method of Woolf.[12] All statistical analyses were performed with a standard statistical package (SAS, Cary, North Carolina). Variables found to have borderline significance on univariable analysis ($p < 0.10$) were included in the multivariable logistic regression analysis.[11] All quantitative data are presented as mean ± SD.

RESULTS

Patients and saphenous vein graft lesions: Excimer laser coronary angioplasty was performed in 495 patients with 545 saphenous vein graft lesions. The average age of the patients was 63 ± 11 years. In all, 381 patients (77%) were men, 332 patients (67%) had unstable angina, and 104 patients (21%) had diabetes mellitus.

The mean graft age was 8.0 ± 2.0 years, and 52% of the lesions were eccentric, 24% were >10 mm in length, 15% were ulcerated, and 12% involved the graft ostium. The mean graft diameter for all patients was 3.2 ± 0.7 mm, whereas the mean graft diameter for those receiving laser-alone treatment was 3.1 ± 0.7 mm (p = NS). Adjunctive treatment included balloon angioplasty at 496 (91%), directional atherectomy at 2 (0.4%), and stent implacement at 0 of the 545 treated sites (Table I). For all patients, the mean diameter stenosis was reduced from 88 ± 13% before treatment to 45 ± 21% after laser, and then to 20 ± 16% at the end of the procedure with adjunctive therapy.

Success: Clinical success was achieved in 455 of 495 patients (92%), as defined by ≤50% stenosis at every target lesion and no major complication at any time during hospitalization (death, Q-wave or non–Q-wave myocardial infarction, abrupt vessel closure, repeat percutaneous transluminal coronary angioplasty, or need for bypass surgery). Logistic regression analysis showed that clinical success was influenced by lesion type (Figure 1). Ostial lesions tended to have increased success (success rate = 95%, adjusted odds ratio [OR] = 2.1 [95% confidence interval (CI) range 0.62, 6.88]; p = 0.24), whereas lesions >10 mm in length had reduced success (success rate = 84%, OR = 0.30 [CI 0.16, 0.56]; p = 0.001). Neither graft age (p = 0.76) nor laser catheter size (p = 0.75) was found to be a predictor of clinical success.

Complications (Table II): At least 1 complication occurred in 30 of 495 patients (6.1%). Five patients died during hospitalization (1.0%), 3 patients were referred

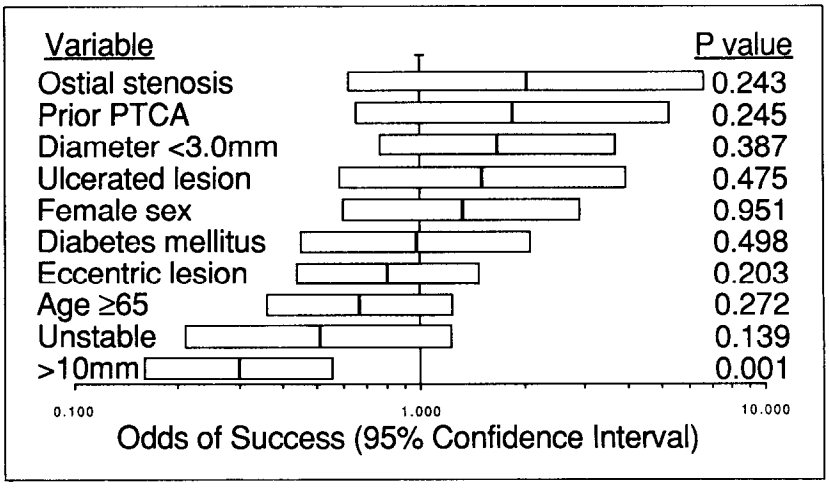

FIGURE 1. Odds ratios and 95% confidence intervals are presented to identify predictors of clinical success in 495 patients with 545 saphenous vein graft lesions. By logistic regression analysis, variables with an odds ratio significantly <1.0 are associated with decreased likelihood of clinical success. >10 mm = lesion length. PTCA = percutaneous transluminal coronary angioplasty.

for repeat bypass surgery (0.6%), 12 patients experienced Q-wave myocardial infarction (2.4%), and 11 patients had non–Q-wave myocardial infarction (2.2%). Eighteen of 545 lesions were associated with embolization (3.3%). Twenty-two lesions were associated with abrupt closure (4.0%). Seven treated sites were associated with graft perforation (1.3%), which was manifest in every case as minor extravasation of contrast medium and successfully sealed with balloon angioplasty without sequelae. No patient experiencing perforation died or required pericardiocentesis or emergency surgery. Major complications from excimer laser angioplasty (death, myocardial infarction, or bypass surgery) were influenced by lesion type (Figure 2). Multivariable logistic regression analysis showed lower likelihood of complications for ostial lesions (complication rate = 0%, OR = 0.10 [CI 0.01, 0.79]; p = 0.03), restenosis lesions (complication rate = 1.2%, OR = 0.24 [CI 0.05, 1.23]; p = 0.07), and lesions in smaller grafts <3.0 mm (complication rate = 2.2%, OR = 0.31 [CI 0.10, 0.94]; p = 0.03). An increased likelihood of complications was seen for lesions >10 mm in length (complication rate = 12%, OR = 3.3 [CI 1.6, 6.6]; p = 0.004). Neither graft age (p = 0.19) nor laser catheter size (p = 0.47) was found to be a predictor of major complications.

Angiographic restenosis: Six-month angiographic follow-up was obtained in 161 of 364 eligible patients (44%). Of the patients with angiographic follow-up, >50% stenosis was seen at 1 or more of the treated sites in 88 patients (55%). Restenosis occurred less often in large grafts ≥3.0 mm (restenosis rate = 50%, adjusted OR = 0.51 [CI 0.25, 1.01]; p = 0.06) than in smaller grafts (Figure 3). Small grafts with lesions >10 mm had restenosis rates of 70%.

DISCUSSION

Atheromatous disease in saphenous vein grafts is histologically similar to that found in native coronary arteries,[13–15] and consists of fibrointimal hyperplasia, atherosclerosis, and thrombus either alone or in combination.[13–16] The accumulation of foam cells and the formation of irregular fibrous caps increase the likelihood of erosion, rupture, and thrombus formation.[1,2,17] Because specific angiographic characteristics of lesions influence the outcome after interventional procedures in native vessels,[6–8,17–19] it is reasonable to propose that angiographic morphology influences outcome after excimer laser treatment of saphenous vein graft lesions.

In this study, we observed that a wide range of saphenous vein graft lesions can be treated with excimer laser

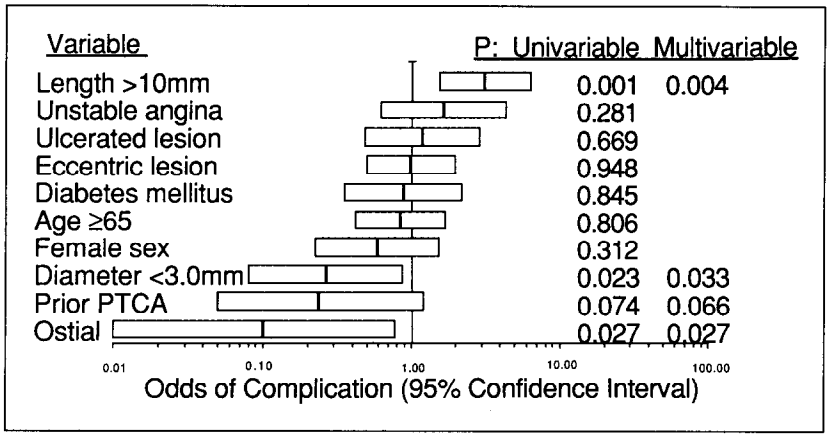

FIGURE 2. Odds ratios and 95% confidence intervals are presented to identify predictors of major complications. Variables with an odds ratio significantly >1.0 are associated with increased likelihood of complication. PTCA = percutaneous transluminal coronary angioplasty.

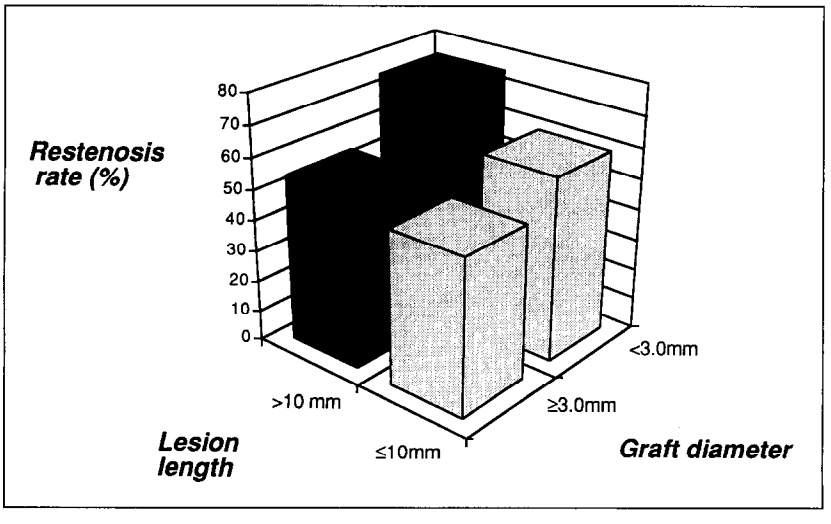

FIGURE 3. Restenosis rates are presented as a function of both lesion length and graft diameter.

angioplasty with an overall success rate of 92%. Lesion morphology and graft dimensions, however, did influence the procedural outcome. We observed that success and complication rates were superior when excimer laser angioplasty was used for ostial lesions of all vein grafts and for discrete stenoses in vein grafts <3.0 mm. After controlling for lesion and graft morphology, we observed no effect of graft age on outcome after excimer laser angioplasty, a finding that differs from the results reported for balloon angioplasty. Using balloon angioplasty for saphenous vein graft lesions, Webb and colleagues[20] achieved clinical success in 119 of 140 patients (85%), which was higher for younger grafts <1 year of age (92%) but lower for proximal sites (80%). Platko and co-workers[4] reported that balloon angioplasty of 48 grafts >3 years of age (mean age of 7.5) had complication rates (4% risk of death, 13% risk of embolization, and 4% risk of bypass surgery) that were significantly higher than those for younger grafts. Dorros et al[21] achieved clinical success with balloon angioplasty in 44 of 53 saphenous vein graft lesions (83%), and observed embolization in 6%. Reeves et al[22] observed clinical success with balloon angioplasty in 47 of 57 patients (82%), and observed evidence of embolization in 11 of 64 grafts (17%). In this study, we observed a 1% risk of death, 3% risk of embolization, and 0.6% risk of bypass surgery for excimer laser treatment of lesions in saphenous vein grafts with a mean age of 8.0 years.

Treatment of saphenous vein graft lesions with directional atherectomy has been associated with embolization in 8 of 91 lesions (9%)[19] and restenosis rates of 53% to 82% for primary and recurrent restenosis lesions.[18] Treatment of saphenous vein graft lesions with transluminal extraction atherectomy has been associated with success in 23 of 29 lesions (79%), but distal embolization occurred in 5 of 22 degenerated grafts (23%).[23] In this study, we observed better success rates for smaller grafts than larger grafts with excimer laser angioplasty, a finding that has also been reported for balloon angioplasty.[24] On the other hand, smaller grafts have not been found to be suitable for endoluminal stenting, a therapy that has been reported, however, to have very good success (96%) and complication (2%) rates in large grafts.[25] Thus, excimer laser angioplasty or balloon angioplasty may complement endoluminal stenting by allowing lesions in a broad range of graft sizes to be treated with various interventional methods.

The current study has a number of limitations. Although each investigator reported all clinical and angiographic results to a core clinical data facility, no core angiographic laboratory was available for analysis of cineangiograms. To ensure uniform reporting, all investigators agreed prospectively on a set of definitions for the morphologic classification of saphenous vein graft lesions. Second, angiographic follow-up was very low at 44% compliance rate. Thus, restenosis rates reported here are inaccurate. However, it is unlikely that the restenosis rates are overrepresented in this report, because symptomatic patients were more likely to comply with the request for 6-month angiographic follow-up than asymptomatic patients. Also, serial creatine kinase measurements were not obtained in asymptomatic patients. Thus, the incidence of silent distal embolization is underestimated by this study.

In conclusion, this study suggests that excimer laser angioplasty can be best used to treat discrete lesions at the ostium of all vein grafts or in the body of smaller saphenous vein grafts. Direct comparison with other interventional methods is required to define the ultimate clinical use of excimer laser angioplasty in saphenous vein graft lesions.

APPENDIX

Centers and Investigators for the Percutaneous Excimer Laser Coronary Angioplasty Registry:

Alabama Heart Institute, Birmingham, Alabama (E. Cohen); Arizona Heart Institute, Phoenix, Arizona (R. M. Siegel); Brigham and Women's Hospital, Boston, Massachusetts (J. A. Bittl); Cornell-New York Hospital, New York, New York (T. A. Sanborn); Crawford Long Hospital, Atlanta, Georgia (D. C. Morris); Duke University Medical Center, Durham, North Carolina (J. E. Tcheng, H. R. Phillips); George Washington University Medical Center, Washington, D.C. (J. Segal); Good Samaritan Hospital, Phoenix, Arizona (N. Laufer); Gunderson Clinic, La Crosse, Wisconsin (J. Bird, R. Green); Memorial Hospital, Colorado Springs, Colorado (C. Kucinski, R. Blonder); Methodist Hospital, Lubbock, Texas (P. Walter, P. Overlie); Mills-Peninsula Hospital, Palo Alto, California (R. Ginsburg); Mt. Sinai Medical Center, Miami Beach, Florida (P. S. Swaye, P. Vignola); New England Deaconess Hospital, Boston, Massachusetts (G. S. Abela); Northwestern Memorial Hospital, Chicago, Illinois (B. Kramer); Penrose-St. Francis Hospital, Colorado Springs, Colorado (J. Kleiner, R. Moothart); Scott & White Clinic, Temple, Texas (L. Watson); Southeast Missouri Hospital, Cape Girardeau, Missouri (C. R. Talbert, J. Chapman); St. Elizabeth's Hospital, Boston, Massachusetts (J. M. Isner); St. Francis Hospital, Roslyn, New York (R. Hershman); St. Francis Medical Center, Pittsburgh, Pennsylvania (J. Power); Tampa General Hospital, Tampa, Florida (S. K. Chokshi); Texas Heart Institute (M. Schnee, R. Leachman); University of California, Irvine Medical Center, Irvine, California (J. Tobis); University of Iowa, Iowa City, Iowa (M. Winniford); University of Michigan Hospital, Ann Arbor, Michigan (S. G. Ellis).

1. de Feyter PJ, van Suylen R-J, de Jaegere PPT, Topol EJ, Serruys PW. Balloon angioplasty for the treatment of lesions in saphenous vein bypass grafts. *J Am Coll Cardiol* 1993;21:1539–1549.
2. Douglas JS Jr. Percutaneous intervention in patients with prior coronary bypass surgery (update 8). In: Topol EJ, ed. Textbook of Interventional Cardiology. Philadelphia: WB Saunders, 1993:119–133.
3. Hirshfeld JW Jr, Schwartz JS, Jugo R, MacDonald RG, Goldberg S, Savage MP, Bass TA, Vetrovec G, Cowley M, Taussig AS. Restenosis after coronary angioplasty: a multivariate statistical model to relate lesion and procedure variables to restenosis. The M-HEART Investigators. *J Am Coll Cardiol* 1991;18:647–656.
4. Platko WP, Hollman J, Whitlow PL, Franco I. Percutaneous transluminal angioplasty of saphenous vein graft stenosis: long-term follow-up. *J Am Coll Cardiol* 1989;14:1645–1650.
5. Litvack F, Grundfest WS, Goldenberg T, Laudenslager J, Forrester JS. Percutaneous excimer laser angioplasty of aortocoronary saphenous vein grafts. *J Am Coll Cardiol* 1989;14:803–808.
6. Cook SL, Eigler NL, Shefer A, Goldenberg T, Forrester JS, Litvack F. Percutaneous excimer laser coronary angioplasty of lesions not ideal for balloon angioplasty. *Circulation* 1991;84:632–643.
7. Bittl JA, Sanborn TA, Tcheng JE, Siegel RM, Ellis SG. Clinical success, com-

plications and restenosis rates with excimer laser coronary angioplasty. *Am J Cardiol* 1992;70:1533–1539.
8. Bittl JA, Sanborn TA. Excimer laser-facilitated coronary angioplasty: relative risk analysis of acute and follow-up results in 200 patients. *Circulation* 1992;86: 71–80.
9. Estella P, Ryan TJ Jr, Landzberg JS, Bittl JA. Excimer laser-assisted angioplasty for lesions containing thrombus. *J Am Coll Cardiol* 1993;21:1550–1556.
10. Ambrose JA, Winters SL, Stern A, Eng A, Teicholz LE, Gorlin R, Fuster V. Angiographic morphology and the pathogenesis of unstable angina pectoris. *J Am Coll Cardiol* 1985;5:609–614.
11. Glantz SA, Slinker BK. Regression with a qualitative dependent variable. In: Glantz SA, Slinker BK, eds. Primer of Applied Regression and Analysis of Variance. New York: McGraw-Hill, 1990:512–568.
12. Kahn HA, Sempos CT. Relative risk and odds ratio. In: Kahn HA, Sempos CT, eds. Statistical Methods in Epidemiology. New York: Oxford University Press, 1989:45–71.
13. Bulkley BH, Hutchins GM. Accelerated "atherosclerosis": a morphologic study of 97 saphenous vein coronary artery bypass grafts. *Circulation* 1977;55:163–169.
14. Barboriak JJ, Pintar K, Korns ME. Atherosclerosis in aortocoronary vein grafts. *Lancet* 1974;2:621–624.
15. Smith SH, Geer JC. Morphology of saphenous vein-coronary artery bypass grafts. *Arch Pathol Lab Med* 1983;107:13–18.
16. Cox JL, Chiasson DA, Gotlieb AI. Stranger in a strange land: the pathogenesis of saphenous vein graft stenosis with emphasis on structural and functional differences between veins and arteries. *Prog Cardiovasc Dis* 1991;34:45–68.
17. Ellis SG, Vandormael MG, Cowley MJ, DiSciascio G, Deligonul U, Topol E, Bulle TM. Multivessel Angioplasty Prognosis Study Group. Coronary morphologic and clinical determinants of procedural outcome with angioplasty for multivessel coronary disease: implications for patient selection. *Circulation* 1990;82:1193–1202.
18. Hinohara T, Robertson GC, Selmon MR, Vetter JW, Rowe MH, Braden I J, McAuley BJ, Sheehan DJ, Simpson JB. Restenosis after directional coronary atherectomy. *J Am Coll Cardiol* 1992;20:623–632.
19. Hinohara T, Rowe MH, Robertson GC, Selmon MR, Braden L, Leggett JH, Vetter JW, Simpson JB. Effect of lesion characteristics on outcome of directional coronary atherectomy. *J Am Coll Cardiol* 1991;17:1112–1120.
20. Webb JG, Myler RK, Shaw RE, Anwar A, Mayo JR, Murphy MC, Cumberland DC, Stertzer SH. Coronary angioplasty after coronary bypass surgery: initial results and late outcome in 422 patients. *J Am Coll Cardiol* 1990;16:812–820.
21. Dorros G, Lewin RF, Mathiak LM, Johnson WD, Brenowitz J, Schmahl T, Tector A. Percutaneous transluminal coronary angioplasty in patients with two or more previous coronary artery bypass operations. *Am J Cardiol* 1988;61:1243–1247.
22. Reeves F, Bonan R, Cote G, Crepeau J, deGuise P, Gosselin G, Campeau L, Lesperance J. Long-term angiographic follow-up after angioplasty of venous coronary bypass grafts. *Am Heart J* 1991;122:620–627.
23. Popma JJ, Leon MB, Mintz GS, Kent KM, Satler LF, Garrand TJ, Pichard AD. Results of coronary angioplasty using the transluminal extraction catheter. *Am J Cardiol* 1992;70:1526–1532.
24. Cote G, Myler RK, Stertzer SH, Clark DA, Fishman-Rosen J, Murphy M, Shaw RF. Percutaneous transluminal angioplasty of stenotic coronary artery bypass grafts: 5 years' experience. *J Am Coll Cardiol* 1987;9:8–17.
25. Pomerantz RM, Kuntz RE, Carrozza JP, Fishman RF, Mansour M, Schnitt SJ, Safian RD, Baim DS. Acute and long-term outcome of narrowed saphenous venous grafts treated by endoluminal stenting and directional atherectomy. *Am J Cardiol* 1992;70:161–167.