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Percutaneous Angioscopy of Saphenous Vein Coronary Bypass Grafts

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Objectives. We compared the results of percutaneous angioscopy and angiography for detecting critical elements of surface lesion morphology in 21 patients undergoing balloon angioplasty of saphenous vein coronary bypass grafts.

Background. Angiography remains the standard for diagnosing and treating intravascular pathology associated with atherosclerotic coronary artery disease. It has been demonstrated that coronary angioscopy is more sensitive for identifying more complex atherosclerotic plaques and intracoronary thrombi in native coronary arteries.

Methods. Angioscopy and angiography were performed before and after angioplasty of "culprit lesions" in bypass grafts. All but one of the patients had unstable angina. The mean age of the saphenous vein coronary bypass grafts was 10.1 ± 2.4 years (range 5 to 15).

Results. Restenosis at a prior angioplasty site was present in seven patients. Intravascular thrombi were seen by angioscopy in 15 (71%) of 21 versus 4 (19%) of 21 grafts by angiography ($p < 0.001$). Dissection was identified by angioscopy in 14 (66%) of 21 versus 2 (9.5%) of 21 grafts by angiography ($p < 0.01$). The presence of friable plaque lining the lumen surface of the vein graft was detected by angioscopy in 11 (52%) of 21 versus 4 (19%) of 21 grafts by angiography ($p < 0.05$). There was no correlation between age of the bypass graft and the finding of friable plaque.

Conclusions. We conclude that angioscopy is superior to angiography for detecting complex lesion morphology in bypass grafts and that the presence of friable plaque does not preclude an uncomplicated angioplasty procedure.

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Angiography remains the reference standard for the diagnosis and treatment of intravascular pathology associated with atherosclerotic coronary artery disease. Catheter-based treatments such as balloon angioplasty, atherectomy and intracoronary thrombolysis are heavily dependent on variables of angiographic lesion morphology to guide therapy. This is particularly true of stenotic saphenous vein coronary bypass grafts, in which angiographic morphologic features such as the location of a lesion within the body of the graft, diffuse lesions and intravascular filling defects have been associated with an increased risk of procedural complications (1–3).

We and others (4,5) have demonstrated that coronary angioscopy, the direct visualization of the endoluminal surface, is more sensitive than is angiography for the identification of complex atherosclerotic plaques and intracoronary thrombi in native coronary arteries. Angioscopy also yields information regarding subtle details of plaque morphology such as the presence or absence of pigmentation as well as specific details of the surface contour of atherosclerotic plaque (that is, smooth, ulcerated or friable) (6).

The purpose of this paper is to describe the angioscopic surface morphology of stenotic saphenous vein coronary bypass grafts and to contrast and compare these findings with angiographic data.

Methods

Patients. Percutaneous angioscopy and angiography were performed before and after balloon angioplasty of a culprit lesion in a saphenous vein coronary bypass graft in 21 selected patients (Table 1). The mean age of the patients was 64.5 ± 6.5 years (range 49 to 74). The mean age of the saphenous vein bypass grafts was 10.1 ± 2.6 years (range 5 to 15). There were 20 men and one woman. Stable angina was present in only 1 patient; the remaining 20 patients met the criteria for unstable angina defined as a recent (≤1 week) increase in the severity or frequency of previously stable angina, postinfarction angina (≤1 week) or angina pectoris at rest. Seven patients had restenosis after prior balloon angioplasty.

Suitable lesions for angioscopy included those occurring in grafts ≤4.0 mm in diameter and a location ≥1.5 cm distal to the proximal anastomosis to allow effective balloon occlusion of anterograde blood flow. All patients were hemodynamically stable and required no vasopressor agents or mechanical assist devices. This protocol was approved by

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Table 1. Patient and Saphenous Vein Graft Information

Pt No.	Age (yr)/ Gender	Angina (S/U)	Restenosis (yes/no)	Lesion Location*	Graft Age (yr)
1	59/M	U	No	Body	10
2	57/M	U	No	Body	10
3	63/M	U	No	Body	13
4	66/M	U	No	Body	15
5	68/M	U	No	Body	5
6	56/M	U	No	Body	8
7	64/M	U	No	Body	10
8	64/M	U	No	Body	10
9	71/F	U	No	Body	6
10	49/M	U	No	Distal	11
11	61/M	U	No	Distal	8
12	66/M	U	No	Body	6
13	73/M	U	No	Distal	10
14	59/M	S	No	Body	12
15	69/M	U	Yes	Distal	14
16	67/M	U	Yes	Body	13
17	74/M	U	Yes	Body	10
18	60/M	U	Yes	Distal	11
19	74/M	U	Yes	Body	10
20	65/M	U	Yes	Body	11
21	70/M	U	Yes	Distal	9

*Lesion within the body of the graft (Body) or involving the distal graft anastomosis (Distal). F = female; M = male; Pt = patient; S = stable angina; U = unstable angina.

our Institutional Review Board, and informed consent was obtained from each patient.

Angioscopic equipment. The coronary angioscope (Advanced Cardiovascular Systems) is a 4.3F polyethylene catheter that closely resembles a balloon angioplasty catheter. The angioscope has four working channels, including one for inflation and deflation of the occlusion balloon (2.5- to 4.0-mm inflated diameter), a lumen to accommodate the 0.2-mm fiber optic image bundle, one channel for the illumination fibers and a guide wire lumen that permits the infusion of clear crystalloid to displace blood from the distal tip of the scope.

The tip of the angioscope can be directed or steered into coaxial alignment with the lumen of tortuous coronary arteries by using a specially designed 0.014-in. (0.036 cm) guide wire with sinusoidal bends in the terminal portion. By withdrawal and rotation of the guide wire, the distal tip of the angioscope is deflected by the bends in the wire. Once the tip of the angioscope is aligned with the vessel lumen, the guide wire may be rotated to allow circumferential viewing of the vascular lumen.

The angioscope has two proximal connectors for coupling 11 illumination fibers to a halogen light source and a 2,000-element fiber-optic imaging bundle is connected to a color television camera. The angioscopic images are displayed on a color video monitor and recorded on 0.75-in. (1.9 cm) videotape.

Angioscopic procedure. The saphenous vein coronary bypass graft with the target lesion was selectively intubated with an 8F coronary angioplasty guiding catheter, and 10,000 U of heparin was administered. Baseline angiography was performed in a minimum of two orthogonal views. The angioscopic wire was advanced across the stenosis and placed in a distal segment of the graft or native coronary artery. The angioscope was then advanced over the guide wire to a location several millimeters *proximal* to the stenosis. The occlusion balloon was inflated with a mixture of radiopaque contrast medium and saline solution to 1 to 3 atm of pressure, and warm Ringer's lactate solution (2 to 10 ml) was infused through the guide wire lumen to clear blood from the field of view. The angioscopic guide wire was manually rotated and withdrawn into the angioscope while viewing until the lumen and lesion were visualized. The guide wire was then rotated to obtain a circumferential view of the culprit lesion. The duration of the occlusion time was 30 to 45 s per imaging attempt. We intentionally did not cross the stenosis with the angioscope before balloon angioplasty was performed to avoid "Dottering" the lesion.

After imaging, the angioscope was exchanged for an angioplasty balloon catheter, and balloon dilation of the culprit lesion was performed. After angioplasty, the angioscope was reinserted and advanced to the dilated segment of the vein graft and into the distal vessel, and imaging was performed. Finally, the angioscope and guide wire were withdrawn and postangioplasty angiography was performed in a minimum of two views corresponding to the baseline angiographic views.

Angiographic lesion morphology. The angiographic criterion for intravascular thrombus was the appearance of a radiolucent filling defect within the lumen of the vein graft. A dissection was identified by the appearance of a linear contrast stain within the wall of the graft. Friability of the graft was determined from the baseline angiogram by the angiographic appearance of a graft with an irregular or serrated lumen border. Percent lumen diameter stenosis before and after percutaneous transluminal coronary angioplasty was determined by electronic calipers comparing the lumen diameter of the stenosis with nearest proximal normal-appearing segment of the graft. The cineangiograms were reviewed by an experienced angiographer (C.J.W.) without knowledge of the angioscopic or clinical information.

Angioscopic lesion morphology. Angioscopic criteria for intraluminal thrombi included the appearance of red material firmly adherent to the vessel wall or a globular red mass suspended within the lumen of the vein graft. Dissections appeared as mobile, whitish fronds of tissue adherent to the vessel wall, or as deep crevices (plaque fractures) extending into the wall of the graft. Friability of the graft was determined from the images obtained before angioplasty and was defined as the presence of fragmented and loosely adherent plaque lining the vessel wall. The angioscopic videotapes were reviewed by an experienced angioscopist (S.R.R.) without knowledge of the angiographic or clinical information.

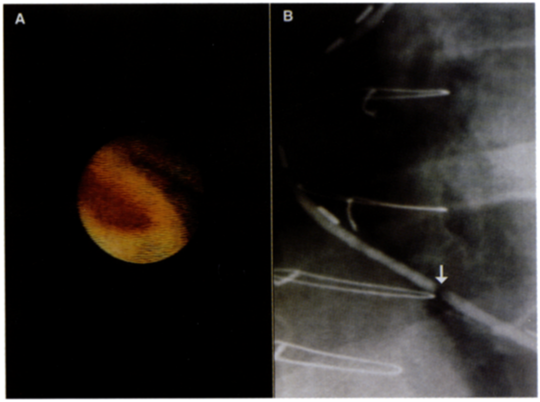


Figure 1. A, Angioscopic view of the vein graft stenosis with a red thrombus present. B, Angiogram of vein graft stenosis (arrow) at the site of angioscopy before coronary angioplasty; no evidence of thrombus is present.

Statistical analysis. Where appropriate, values are expressed as the mean value ± SD. Continuous variables were analyzed with the Student *t* test and categoric variables were compared by chi-square analysis. A probability value of < 0.05 was accepted as evidence of a significant difference.

Results

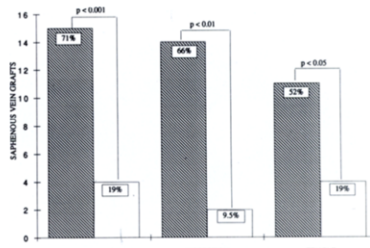
Angioplasty results. All 21 patients had successful angioplasty procedures that reduced the culprit stenosis by >20% with a residual diameter stenosis of <50% without a complication. No patients had clinical or angiographic evidence of distal embolization after angioplasty. During angioscopic viewing, some patients had transitory ECG evidence of ischemia or chest pain, or both, that resolved with deflation of the angioscopic balloon and restoration of flow.

Intracoronary thrombi. Combining data obtained before and after angioplasty, angioscopy demonstrated the presence of intravascular thrombi (Fig. 1) in 15 (71%) of 21 grafts as opposed to only 4 (19%) detected by angiography ($p < 0.001$) (Fig. 2). The incidence of intracoronary thrombi detected by angioscopy did not differ between the restenosis graft lesions (71%; 5 of 7) and the primary graft lesions (71%; 10 of 14). There was no correlation between the age of a bypass graft and the presence of thrombus.

Dissection. Dissection was seen either before or after angioplasty in 14 grafts (66%) by angioscopy versus 2 grafts (9.5%) by angiography ($p < 0.01$) (Fig. 2). No patients had angiographic evidence of dissection before angioplasty, whereas seven patients had intimal tears seen with angioscopy before angioplasty. After angioplasty, 2 dissections (9.5%) were seen with angiography, whereas 11 (52.3%) were seen with the angioscope (Fig. 3). The presence of dissection did not correlate with the age of the bypass graft.

Friability. Graft friability was detected bef[illegible] plasty by angioscopy (Fig. 4) in 11 grafts (52.3[illegible] with only 4 grafts (19%) by angiography ($p < 0.05$) [illegible] Graft age did not correlate with the presence of graft friability. Pigmentation of the plaque was present in 10 (71%) of 14 primary lesions versus 4 (57%) of 7 restenosis lesions (p = NS). Angioscopy confirmed the presence of a friable plaque in three of four grafts identified by angiography. The graft incorrectly identified as friable by angiography had a

Figure 2. Comparison of angioscopic (hatched bars) and angiographic (white bars) findings of thrombus, dissection and graft friability (n = 21).



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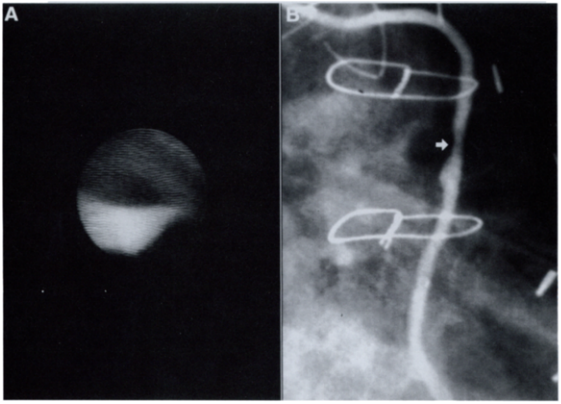

Figure 3. A, Angioscopic view of midbody vein graft stenosis after coronary angioplasty showing the lumen and a white tissue flap (dissection). B, Angiogram of vein graft after angioplasty with lesion site (arrow) without dissection.

complex lesion with a white fibrotic nonshaggy-appearing intimal lining by angioscopy.

Discussion

Our data demonstrate the ability of angioscopy to detect features of lesion morphology that are frequently not seen by angiography in saphenous vein coronary bypass grafts. This observation is consistent with prior studies (7–9) in native coronary arteries in patients with unstable angina or non-Q wave myocardial infarction that have shown relative insensitivity of angiography for detecting intraluminal pathologic features such as intracoronary thrombus and plaque rupture. Angiography has also been reported (10–12) to lack precision in documenting the presence of thrombus or dissection in patients undergoing coronary angioplasty. The sensitivity of angiography for any surface morphology will depend on the magnitude of the finding. It is quite easy to understand

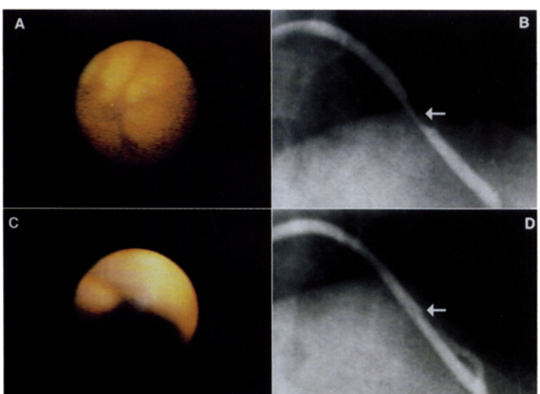

Figure 4. A, Angioscopic view before coronary angioplasty showing loosely arranged friable yellow plaque. B, Angiogram before angioplasty does not show friability of the lesion. C, Angioscopic view after angioplasty revealing an improved lumen diameter and displacement of the friable plaque. D, Angiogram after angioplasty shows an excellent result and no evidence of plaque disruption or embolization.

the insensitivity of angiography for mural thrombi or superficial dissections that may be easily visualized by angioscopy but not detected by angiography. In our patients angioscopy proved to be more accurate than angiography in detecting the presence of intraluminal thrombi, dissections and friability of the endoluminal surface. This superior sensitivity of angioscopy over angiography for identifying intraluminal morphology is consistent with results obtained in native coronary arteries (4,5).

The angiographic appearance of friable lesions or diffuse disease in saphenous vein coronary bypass grafts has been suggested to be a relative contraindication to balloon angioplasty because of the increased risk of distal embolization of atherosclerotic material (2,3). Histologic studies (13–15) of saphenous vein bypass graft stenoses demonstrate the progression from fibrointimal proliferation in early graft lesions (<1 year old) to the development of typical atherosclerotic plaque in grafts >3 years old. These plaques differ very little in their composition from native coronary artery atherosclerotic lesions with the exception that the plaques may be larger in ectatic saphenous vein grafts and, because of their bulk, may be more likely to cause clinically significant embolization during angioplasty (13). There are reports (1,3,13,16) that angioplasty of saphenous vein bypass grafts >3 years old (atherosclerotic versus fibrotic lesions) has been associated with increased risk of distal embolization. However, other investigators (17–21) have not confirmed the increased association of angioplasty complications with any specific angiographic lesion morphology in bypass grafts or an association of older vein grafts with an increased risk of procedural complications.

This uncertainty regarding the risk of embolization and the questionable ability of angiography to identify a high risk subgroup for bypass graft angioplasty may be related to the insensitivity of angiography for detecting friable lesions, as we have shown. None of our patients, including the 11 patients with demonstrable friability of the lumen surface by angioscopy, experienced embolization associated with angioplasty of these older vein grafts. Furthermore, we could not demonstrate that the presence of a friable surface correlated with the age of the bypass graft.

Summary. We have demonstrated that the incidence of intravascular thrombi, dissection and plaque friability are underestimated by angiography in saphenous vein bypass grafts. We have also shown that the angioscopic identification of friable plaque does not preclude an uncomplicated angioplasty procedure, and that in these older grafts there is no correlation between their absolute age and the presence of friable plaque. To determine whether the angioscopic appearance of plaque can predict in which grafts atheroembolism is more likely to occur will require study of a larger number of patients.

References

1. Reeves F, Bonan R, Cote G, et al. Long-term angiographic follow-up after angioplasty of venous coronary bypass grafts. Am Heart J 1991;122:620–7.
2. Cote G, Myler RK, Stertzer SH, et al. Percutaneous transluminal angioplasty of stenotic coronary artery bypass grafts: 5 years' experience. J Am Coll Cardiol 1987;9:8–17.
3. Block PC, Cowley MJ, Kaltenbach M, Kent KM, Simpson J. Percutaneous angioplasty of bypass grafts or of bypass graft anastomotic sites. Am J Cardiol 1984;53:666–8.
4. Ramee SR, White CJ, Collins TJ, Mesa J, Murgo JP. Percutaneous angioscopy during percutaneous coronary angioplasty using a steerable microangioscope. J Am Coll Cardiol 1991;17:100–5.
5. Sherman CT, Litvack F, Grundfest W, et al. Coronary angioscopy in patients with unstable angina pectoris. N Engl J Med 1986;315:913–9.
6. White CJ, Ramee SR, Mesa J, Collins TJ. Percutaneous coronary angioscopy in patients with restenosis after coronary angioplasty. J Am Coll Cardiol 1991;17:46B–9B.
7. Ambrose JA, Winters SL, Stern A, et al. Angiographic morphology and the pathogenesis of unstable angina pectoris. J Am Coll Cardiol 1985;5:609–16.
8. Bresnahan DR, Davis JL, Holmes DR Jr, Smith HC. Angiographic occurrence and clinical correlates of intraluminal coronary artery thrombus: role of unstable angina. J Am Coll Cardiol 1985;6:285–9.
9. Ambrose JA, Hjemdahl-Monsen CE, Borrico S, Gorlin R, Fuster V. Angiographic demonstration of a common link between unstable angina pectoris and non-Q wave myocardial infarction. Am J Cardiol 1988;61:244–7.
10. Block PC, Myler RK, Stertzer S, Fallon JT. Morphology after transluminal angioplasty in human beings. N Engl J Med 1981;305:382–5.
11. Duber C, Jungbluth A, Rumpelt HJ, Erbel R, Meyer J, Thoenes W. Morphology of the coronary arteries after combined thrombolysis and percutaneous transluminal coronary angioplasty for acute myocardial infarction. Am J Cardiol 1986;58:698–703.
12. Essed CE, van den Brand M, Becker AE. Transluminal coronary angioplasty and early restenosis: fibrocellular occlusion after wall laceration. Br Heart J 1983;49:393–6.
13. Saber RS, Edwards WD, Holmes DR, Vlietstra RE, Reeder GS. Balloon angioplasty of aortocoronary saphenous vein bypass grafts: a histopathologic study of six grafts from five patients, with emphasis on restenosis and embolic complications. J Am Coll Cardiol 1988;12:1501–9.
14. Waller BF, Rothbaum DA, Gorfinkel HJ, Ulbright TM, Linnemeier TJ, Berger SM. Morphologic observations after percutaneous transluminal balloon angioplasty of early and late aortocoronary saphenous vein bypass grafts. J Am Coll Cardiol 1984;4:784–92.
15. Garratt KN, Edwards WD, Kaufmann UP, Vlietstra RE, Holmes DR. Differential histopathology of primary atherosclerotic and restenotic lesions in coronary arteries and saphenous vein bypass grafts: analysis of tissue obtained from 73 patients by directional atherectomy. J Am Coll Cardiol 1991;17:442–8.
16. 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;14:1645–50.
17. 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 grafting operations. Am J Cardiol 1988;61:1243–7.
18. Marquis JF, Schwartz L, Brown R, et al. Percutaneous transluminal angioplasty of coronary saphenous vein bypass grafts. Can J Surg 1985;28:335–7.
19. Jost S, Gulba D, Daniel WG, et al. Percutaneous transluminal angioplasty of aortocoronary venous bypass grafts and effect of the caliber of the grafted coronary artery on graft stenosis. Am J Cardiol 1991;68:27–30.
20. Reeder GS, Breshnahan JF, Holmes DR Jr, et al. Angioplasty for aortocoronary bypass graft stenosis. Mayo Clin Proc 1986;61:14–9.
21. Ernst SM, van der Felts TA, Ascoop CA, et al. Percutaneous transluminal coronary angioplasty in patients with prior coronary artery bypass grafting. long-term results. J Thorac Cardiovasc Surg 1987;93:268–75.