Which Variable of Stenosis Severity Best Describes the Significance of an Isolated Left Anterior Descending Coronary Artery Lesion?

Correlation Between Quantitative Coronary Angiography, Intracoronary Doppler Measurements and High Dose Dipyridamole Echocardiography

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Objectives. This study sought to investigate the angiographic or intracoronary Doppler variables of stenosis severity that best correlate with the results of dipyridamole echocardiography.

Background. Quantitative coronary angiography and intracoronary Doppler flow velocity assessments are the commonly used techniques for the objective identification of significant coronary artery stenosis.

Methods. Thirty patients with an isolated lesion of the left anterior descending coronary artery (LAD) were studied by means of on-line quantitative coronary arteriography, intracoronary Doppler flow velocity measurements and dipyridamole echocardiography 6 months after percutaneous transluminal coronary angioplasty. The quantitative arteriographic analyses were performed on-line; post-stenotic Doppler flow velocities were measured at baseline and after adenosine infusion. Angiographic and Doppler measurements were compared with the corresponding dipyridamole echocardiographic data and analyzed by discriminant analysis.

On-line quantitative coronary angiography and intracoronary Doppler flow velocity studies are the commonly used techniques for the objective assessment of the severity of coronary artery stenosis during catheterization (1–5). Computer-assisted edge detection methods have been developed to reduce the inherent inaccuracy of visual assessments (6). On-line quantitative coronary angiography is gaining wide acceptance in routine clinical practice, providing angiographers with quantitative morphologic data useful for diagnostic decision making. Among the angiographic variables, stenotic flow reserve obtained by means of quantitative coronary arteriography provides a measure of the integrated anatomic–geometric severity of stenoses on arteriograms that is independent of physiologic variables (7,8).

The use of an intracoronary Doppler guide wire allows the routine evaluation of coronary flow velocity indexes distal to a coronary stenosis, thus providing an alternative means of assessing lesion severity during coronary arteriography (4,5,9–15). Several groups of investigators have examined the relation between the results of the noninvasive tests commonly used to detect ischemia and those of quantitative coronary angiography or intracoronary Doppler guide wire measurements (16–20). However, the integrated value of both techniques in the same cohort of patients has not yet been evaluated. Accordingly, we planned the current study of patients with isolated left anterior descending coronary artery (LAD) stenoses to investigate the variable of stenosis severity that best correlates with the development of transient contraction asynchrony during dipyridamole echocardiography and using angiographic and intracoronary Doppler variables.

Results. The dipyridamole echocardiographic response was positive in 11 patients (37%). The best cutoff values for predicting an abnormal echocardiographic response were 1) stenotic flow reserve of 2.8 (p = 0.0001); 2) 59% diameter stenosis (p = 0.0001); 3) minimal lumen diameter of 1.35 mm (p = 0.001); 4) coronary flow reserve of 2.0 (p = 0.0002); and 5) maximal peak velocity of 60 cm/s during hyperemia (p = 0.04). Multivariate analysis identified stenotic flow reserve as the only independent predictor of ischemia during dipyridamole echocardiography.

Conclusions. Stenotic flow reserve is the variable that best describes the functional significance of an isolated LAD lesion, and a value of 2.8 is the best predictor of a positive dipyridamole echocardiographic response. Furthermore, angiographic variables of stenosis severity relate to echocardiographic test results better than intracoronary Doppler variables.

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Methods

We studied 30 patients (24 men, 6 women; mean ± SD age 61 ± 12 years) who were enrolled in follow-up studies after successful percutaneous transluminal coronary angioplasty and were scheduled for a 6-month angiographic evaluation. At the time of angioplasty, no patient had undergone intracoronary stent implantation or treatment with any other percutaneous devices. To be eligible for the study, each patient was required to have an isolated lesion in the LAD; no clinical history or electrophysiologic evidence of a previous myocardial infarction; normal ventricular function; and no echocardiographic evidence of left ventricular hypertrophy. In this small study cohort, no patient was excluded because of an inadequate acoustic window or technically poor images during stress echocardiography. All patients underwent coronary arteriography with on-line quantitative measurements, intracoronary Doppler guide wire assessments distal to the lesion and high dose dipyridamole echocardiography within 2 days of cardiac catheterization. Antianginal therapy was stopped ≥48 h before testing.

High dose dipyridamole stress echocardiography. Dipyridamole was intravenously infused at a dose of 0.56 mg/kg body weight over 4 min, followed by 4 min of no dose and then a subsequent dose of 0.28 mg/kg for 2 min, according to the standard infusion protocol used in vasodilation stress echocardiography (21). During the procedure, blood pressure and a 12-lead ECG were recorded at each minute. Cross-sectional echocardiograms were continuously monitored and recorded during, and for 10 min after, dipyridamole infusion. All patients received intravenous aminophylline (70 to 240 mg) at during, and for 10 min after, dipyridamole infusion. All patients received intravenous aminophylline (70 to 240 mg) at the end of the test. The positivity of the test was linked to the detection of transient contraction asymmetry. The left ventricle was divided into 16 segments, as proposed by the American Society of Echocardiography (22). Segmental wall motion was graded as follows: 1 = normal; 2 = hypokinesia; 3 = akinesis; and 4 = dyskinesia. The wall motion score index was derived by summing the individual segment scores and dividing the result by the number of interpreted segments. In the positive tests, the dipyridamole time (obtained by the number of minutes from the beginning of drug infusion to the development of stress-induced dyssynergy) was also evaluated. In the negative tests, the dipyridamole time was arbitrarily assumed to be 15 min when aminophylline was given. Videotapes were analyzed by two independent observers (G.R.G., D.M.) who had no knowledge of the clinical and angiographic data; in the case of any disagreement, a third observer (S.P.) reviewed the study, and the majority judgment was accepted.

Coronary angiography. Coronary angiography was performed using the femoral approach with an 8F Judkins catheter after the infusion of 200 μg of nitroglycerin. At least four views were acquired for the left coronary system (including two orthogonal views). Additional appropriate projections were obtained in the case of the superimposition of side branches or a foreshortening of the involved segment.

On-line quantitative coronary angiographic data analysis. On-line quantitative coronary measurements were performed using the Automated Coronary Analysis (ACA) package for the Philips Digital Cardiac Imaging (DCI) System (Philips, Eindhoven, The Netherlands) (23). This analytic software package has been validated and described in detail elsewhere. Briefly, the selection of the coronary segment to be analyzed requires the user to indicate the beginning and the end point of the segment. The contour detection technique is performed by taking the first and second derivative values of brightness profiles calculated along the scan lines perpendicular to the model and by applying the minimal cost contour detection algorithm. To obtain absolute measurements of vessel size, image calibration was performed on the contrast catheter of that particular arteriographic run, with all measurements being made using end-diastolic frames with optimal vessel opacification. Stenotic flow reserve was automatically derived from the length and percent of the stenosis and the absolute diameters and shape of the angiographic image, assuming standardized values for aortic pressure and normal maximal coronary flow, as a way of compartmentalizing the stenosis itself separate from the rest of the cardiovascular system, according to Kirkeide et al. (8). In our laboratory, the intraobserver and interobserver variabilities of on-line quantitative coronary angiographic measurements were tested using the same frame in 25 coronary stenoses. The points for the start and end of the segment to be measured were conventionally placed 5 mm before and after the stenosis borders. Using this approach, the intraobserver and interobserver variabilities were 1.1 ± 9.7% and 1.5 ± 9.2% for percent diameter stenosis, 1.1 ± 11.6% and 2.3 ± 6.9% for minimal lumen diameter and 1.7 ± 19.3% and 3.4 ± 11% for stenotic flow reserve, respectively. Percent diameter stenosis, minimal lumen diameter, reference diameter of the adjacent normal segments and stenotic flow reserve were calculated as the mean of the values obtained in two orthogonal views.

Coronary flow velocity measurements. Flow velocity measurements were obtained by using a previously validated method (4), with a 0.0014-in. (0.0035-cm) steerable Doppler guide wire (Cardiometrics, Inc.) (length 175 cm) with a 12-MHz piezoelectric ultrasound transducer integrated into its tip, allowing a velocity acquisition with a high pulse repetition frequency from a sampling depth of 5 mm. The forward-directed, 25° divergent-angle ultrasound beam samples a large portion of the coronary profile. Blood flow velocities are determined from the Doppler frequency shift based on the difference between the transmitted and returning signals calculated by means of the Doppler equation. The velocity data are processed by on-line fast Fourier transformation. All measurements were obtained at the conclusion of coronary angiography, while the Doppler guide wire was carefully
advanced to a position 2 to 3 cm distal to the stenosis to avoid placement in a side branch or post-stenotic velocity jet. Baseline time-averaged peak velocity and the diastolic/systolic flow velocity ratio were recorded. Furthermore, flow velocity spectra were recorded for 60 s after the bolus administration of 18 μg of adenosine. Distal coronary flow reserve was calculated as the ratio of hyperemic and baseline average peak velocity. The reproducibility of Doppler flow measurements in our laboratory was tested in 18 coronary stenoses. The evaluation was performed in duplicate, separated by 5-min intervals, with the wire being placed in exactly the same position. The variability was 0.3 ± 6.9% for coronary flow reserve, 1.5 ± 14.1% for average peak velocity and 1.6 ± 10.7% for maximal peak velocity during hyperemia.

Statistical analysis. Results are expressed as mean value ± SD. To assess statistically significant differences, the Student t test was used for unpaired data. The angiographic variables (percent diameter stenosis, minimal lumen diameter and stenotic flow reserve) and the flow velocity variables (diastolic/systolic flow velocity ratio, maximal peak velocity during hyperemia and distal coronary flow reserve) were correlated with the dipyridamole stress echocardiographic test results and analyzed by means of discriminant analysis. Univariate and multivariate analyses were carried out using the statistical package for the Social Science (SPSS, SPSS Inc.) and Biomedical Computer Program (BMDP, Statistical Software Inc.). The limited sample size makes it difficult to apply the split-sample validation—that is, to estimate the discriminant function on a subset of the data (the training set) and then to test the out of sample classification performance of the derived discriminant function on the remaining part of the data (the test set). We applied leave-one-out cross-validation to circumvent the over-optimistic classification generated by using the same data set for estimating and testing the discriminant function. In practice, the analysis is repeated a number of times equal to the observations in the data set, leaving, in turn, one observation out of the data used for the estimation. Then, the excluded observation classifications are pooled to produce an overall test classification. For the best discriminant variable, we also carried out a split-sample analysis using a 2:1 and a 1:1 ratio for the training and test set, respectively.

The variability of stenotic flow reserve, percent diameter stenosis and coronary flow reserve with respect to dipyridamole stress echocardiographic time was analyzed separately in patients who had a positive or negative result on the dipyridamole stress echocardiographic test. The test-positive patients were analyzed by linear regression models, and the test-negative group was compared by evaluating the coefficient of variation. Stenotic and coronary flow reserves were compared using a simple linear regression model. A p value <0.05 was considered significant.

Results

The clinical and angiographic characteristics of the study group are summarized in Table 1. The results of angiographic and Doppler measurements, as well as those of dipyridamole stress echocardiography, are reported in Table 2.

High dose dipyridamole echocardiography. Transient contraction asynergy was detected in 11 patients (37%). Echocardiographic positivity was achieved after the low dose of dipyridamole (0.56 mg/kg) in four patients and after the high dose in seven patients. In the 11 patients with positive studies, the time to asynergy was 8.9 ± 2.1 min (range 5 to 12), and the wall motion score index at peak dipyridamole was 1.25 ± 0.11.

On-line quantitative coronary angiography. Eighteen stenoses were located in the proximal segment and 12 in the mid-third of the LAD. The mean percent diameter stenosis was 48.2 ± 21.19% (range 11.4% to 92.2%). The percent diameter stenosis was ≤30% in 7 patients, between 31% and 60% in 13 patients and >60% in the remaining 10 patients. The mean minimal lumen diameter was 1.5 ± 0.7 mm (range 0.28 to 2.95). The mean stenotic flow reserve was 3.25 ± 1.4 (range 0.70 to 4.9). The mean vessel reference diameter was 2.95 ± 0.4 mm and was not statistically different between the patients with a negative (2.92 ± 0.4 mm) and a positive dipyridamole echocardiographic response (3.01 ± 0.5 mm).

Coronary flow velocity measurements. The mean time-averaged peak flow velocity was 22 ± 15 cm/s (range 5 to 68) and was not statistically different between patients with a negative (23 ± 17 cm/s) and a positive dipyridamole echocardiographic response (20 ± 10 cm/s). The mean diastolic/systolic flow velocity ratio was 1.7 ± 0.6 (range 0.5 to 3.1). The mean maximal peak velocity during hyperemia was 75 ± 56 cm/s (range 16 to 234 cm/s). The mean distal coronary flow reserve was 2.33 ± 1.0 (range 1.1 to 5.6).

Correlations between dipyridamole echocardiography, quantitative coronary angiography and intracoronary Doppler measurements. By discriminant analysis, the best angiographic cutoff values for predicting an abnormal echocardiographic test response were 1) stenotic flow reserve of 2.8 (sensitivity 100%, specificity 90%, p = 0.001); 2) percent diameter stenosis of 59% (sensitivity 91%, specificity 95%, p = 0.0001); and 3) minimal lumen diameter of 1.35 mm (sensitivity 100%, specificity 74%, p = 0.0001) (Table 3, Fig. 1).

For coronary flow velocity indexes, the best cutoff values for predicting an abnormal echocardiographic test response were 1) coronary flow reserve of 2.0 (sensitivity 91%, specificity
84%, p = 0.0002); and 2) maximal peak velocity during hyperemia of 60 cm/s (sensitivity 73%, specificity 47%, p = 0.04) (Table 3, Fig. 1).

Multivariate analysis identified the angiographically derived stenotic flow reserve as the only independent variable for the prediction of ischemia during dipyridamole echocardiography (sensitivity 100%, specificity 90%, p = 0.0001).

Good correlation was found between angiographically predicted stenotic flow reserve and the coronary flow reserve measured distal to the stenosis ($r^2 = 0.46$, p = 0.0001) (Fig. 2). Within the zone of a positive dipyridamole test, a linear relation was found to be statistically significant with regard to dipyridamole echocardiographic time in the analyses taking stenotic flow reserve and percent diameter stenosis as the response variables ($p = 0.0196$, $r^2 = 0.51$ and $p = 0.0214$, $r^2 = 0.50$, respectively); no such relation was supported by the data when coronary flow reserve was the response variable considered. Within the zone of a negative dipyridamole test, stenotic flow reserve showed the least spread of data (coefficient of variation 19%, 42% and 34% for stenotic flow reserve, percent diameter stenosis and coronary flow reserve, respectively) (Fig. 3). When the results of both positive and negative tests were analyzed, stenotic flow reserve and percent diameter stenosis

| Table 2. Angiographic, Intracoronary Doppler Flow Velocity and Dipyridamole Stress Echocardiographic Data for 30 Study Patients |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pt No./ Gender | Age (yr) | %DS | MLD (mm) | Ref Diam (mm) | APV (cm/s) | DSVR | MPV (cm/s) | CFR | Response | Time (min) | WMSI |
| 1/M 65 | 66.40 | 1.01 | 2.1 | 3.02 | 14 | 1.48 | 31 | 1.5 | Pos | 12 | 1.18 |
| 2/M 48 | 62.00 | 0.97 | 1.5 | 2.59 | 15 | 1.87 | 32 | 1.3 | Pos | 11 | 1.25 |
| 3/M 68 | 81.30 | 0.58 | 0.6 | 3.11 | 14 | 1.20 | 29 | 1.3 | Pos | 8 | 1.37 |
| 4/F 64 | 66.60 | 1.14 | 1.8 | 3.43 | 27 | 1.79 | 50 | 1.2 | Pos | 9 | 1.12 |
| 5/M 52 | 92.20 | 0.28 | 0.1 | 3.71 | 20 | 0.55 | 42 | 1.1 | Pos | 5 | 1.43 |
| 6/M 66 | 65.90 | 1.07 | 1.8 | 3.17 | 34 | 0.98 | 86 | 1.7 | Pos | 8 | 1.25 |
| 7/M 44 | 71.40 | 0.82 | 1.3 | 2.88 | 6 | 1.09 | 16 | 1.4 | Pos | 9 | 1.25 |
| 8/M 77 | 72.80 | 0.96 | 2.1 | 3.54 | 13 | 1.86 | 24 | 1.6 | Pos | 11 | 1.12 |
| 9/F 59 | 55.90 | 0.94 | 2.8 | 2.15 | 14 | 1.04 | 53 | 2.4 | Pos | 10 | 1.18 |

APV = average peak velocity; CFR = coronary flow reserve; DS = diameter stenosis; DSVR = diastolic/systolic velocity ratio; Echo = echocardiography; F = female; M = male; MLD = minimal lumen diameter; MPV = maximal peak velocity during hyperemia; Neg = negative; Pos = positive; QCA = quantitative coronary angiography; Ref Diam = reference diameter; SFR = stenotic flow reserve; WMSI = wall motion score index.

| Table 3. Results of Discriminant Analysis |
|---|---|---|---|---|---|
| Variable | Sens (%) | Spec (%) | Acc (%) | Cutoff Value | p Value |
| SFR | 100 | 90 | 93 | 2.8 | 0.0001 |
| %DS | 91 | 95 | 93 | 59 | 0.0001 |
| MLD (mm) | 100 | 74 | 83 | 1.35 | 0.0001 |
| CFR | 91 | 84 | 87 | 2 | 0.0002 |
| MPV (cm/s) | 73 | 47 | 57 | 60 | 0.004 |
| DSVR | — | — | — | — | NS |

Acc = accuracy; Sens = sensitivity; Spec = specificity; other abbreviations as in Table 2.
correlated better with dipyridamole echocardiographic time than with coronary flow reserve in the positive subgroup, whereas in the negative subgroup, stenotic flow reserve showed a reduced variability with respect to the other two variables. Thus, stenotic flow reserve appears, globally, to be the most reliable predictor of the dipyridamole echocardiographic results.

**Discussion**

_Two major findings can be drawn from our study:_ 1) In this selected patient cohort, angiographically derived stenotic flow reserve was the variable of stenosis severity that best described the functional significance of an isolated LAD stenosis, and a value of 2.8 was the best predictor of a positive dipyridamole echocardiographic response. 2) The angiographic variables of stenosis severity correlated better with the results of dipyridamole echocardiography than with intracoronary Doppler variables.

**Reference standard in stress testing.** Myocardial ischemia is the result of a supply–demand imbalance between coronary blood flow and myocardial metabolic requirements, which leads to a sequence of events in which blood flow maldistribution between territories supplied by stenotic and nonstenotic coronary arteries precedes the development of regional wall motion abnormalities and is followed by ECG changes and angina (24–26).

The noninvasive identification of coronary artery disease is based on the detection of stress-induced markers of myocardial ischemia. These markers include ECG ST-T wave changes, perfusion defects on myocardial scintigraphy and regional wall motion abnormalities. Echocardiographic imaging, combined with exercise or pharmacologic stimuli, is increasingly being used for the diagnosis of coronary artery disease (27). Stress echocardiography has been shown (28,29) to provide useful information on the presence, severity and distribution of coronary artery disease, with a sensitivity and specificity comparable to that for radionuclide techniques. Among the different types of stress proposed, pharmacologic vasodilation by dipyridamole is widely used in the clinical setting because of its well established safety and accuracy in detecting single-vessel and multivessel disease (30).
The high dose protocol is necessary to increase echocardiographic test sensitivity (21); it has also been shown (31) that high dose dipyridamole leads to the same degree of vasodilation as that obtained during intracoronary adenosine infusion. Comparison with previous studies. The concept of angiographic stenotic flow reserve was first proposed by Gould et al. (7) and Kirkeeide et al. (8) as a simple and integrated functional measurement of stenosis severity, reflecting all its geometric dimensions. In experimental studies, this index proved to be highly specific, reproducible and independent of physiologic conditions when applied to a discrete proximal lesion, as in the case of our group of patients; in different clinical situations (presence of multiple lesions or diffuse atherosclerotic disease and acute coronary syndromes with ulcerated plaque), this method is less reliable (7).

In the clinical setting, the correlations between angiographically derived stenotic flow reserve and intracoronary Doppler coronary flow reserve have been poorly investigated. Recently, Tron et al. (32) found no correlation between these two variables in a heterogeneous patient group. These results may be explained by the inherent limitations of both angiographic and Doppler flow velocity assessments in specific clinical situations. Soon after acute myocardial infarction, coronary flow reserve can no longer be considered a specific marker of lesion severity, because it is affected by the temporary impairment of the microcirculation (7,33,34). In the case of coronary angioplasty, angiography is an inaccurate means of evaluating the immediate procedural result because of the presence of possibly underestimated or undetected intimal tears or dissections that can interfere with the correct measurement of all morphologically derived determinants of lesion severity, such as stenotic flow reserve (35). For this reason, the use of different techniques, such as intravascular ultrasound or Doppler flow velocity studies, have been proposed (36). Unfortunately, in many patients, coronary flow reserve fails to return to normal levels immediately after angioplasty and therefore may not be useful for determining the significance of residual epicardial stenosis (37).

The results of our study were obtained in a selected group of patients with single-vessel coronary artery disease and normal ventricular function to assess the true value of quantitative coronary angiography and intracoronary Doppler measurements in predicting an abnormal response to dipyridamole echocardiography. This selected cohort may explain the good correlation we found between angiographically derived flow reserve and coronary flow reserve measured distal to the stenosis in our patients.

Angiographic and intracoronary Doppler measurements should therefore be considered complementary rather than competitive approaches for describing the relevance of a given coronary stenosis. Stenotic flow reserve reflects only the relative lesion-related impairment of coronary flow reserve and not that of absolute coronary flow reserve, a value reflecting both epicardial and myocardial flow capacity (7). The presence of microvascular disease (which cannot be detected by stenotic flow measurements) could explain the low values of Doppler coronary flow reserve found in 2 of the 19 patients with a negative dipyridamole echocardiographic response.

Regarding the second finding of our study, and similar to Picano et al. (38,39), we found good correlation between the angiographic variables and dipyridamole time, which provides an indirect estimate of the physiologic severity of coronary reserve impairment (Fig. 3).

Furthermore, among the angiographic variables, percent diameter stenosis proved to be superior to minimal lumen
diameter in characterizing the functional significance of a coronary stenosis. These data are in agreement with those of previously reported studies in patients with limited coronary artery disease (40–42). The greater accuracy of percent diameter stenosis (obtained by the mean values of two measures: minimal diameter and “normal” reference diameter) over minimal lumen diameter can be explained by the fact that, at least theoretically, the larger the number of geometric variables considered, the closer the relation with the functional assessment of the narrowing. This finding also suggests that in the presence of diffuse coronary disease, multiple measurements may amplify the effect of measurement errors and lead to a weaker functional depiction of the narrowing.

However, our angiographic cutoff values are slightly different from those observed by Arnese et al. (42), who looked at the diagnostic accuracy of angiographic variables for the prediction of an abnormal scintigraphic or exercise echocardiographic test response. This difference may be partially explained by the fact that the off-line quantification used by Arnese et al. relied on a higher degree of spatial resolution of the 35-mm cine film than that of the digitally acquired arteriograms we used.

The decision to use dipyridamole echocardiography for the noninvasive detection of ischemia can explain the good accuracy of both stenotic and coronary flow reserve in predicting an abnormal response to stress echocardiography that we observed in our patients. This choice may also explain the differences between our results and those of previous studies (12,16,20) in which angiographic or geometric descriptors of coronary obstruction did not correlate with stress-induced ischemia or coronary flow reserve by Doppler echocardiography. Those studies used exercise stress to an ischemic end point, particularly exercise thallium-201 perfusion imaging (12,20).

During exercise stress testing, regional left ventricular myocardial ischemia may result not only from an increase in myocardial oxygen demand (43), but also from the limitation of coronary flow as a result of coronary vasoconstriction and the inability of vasodilatation to occur near the site of an atherosclerotic plaque (44).

The most important mechanism involved in the development of dipyridamole-induced ischemia is the flow maldistribution resulting from inappropriate coronary artery vasodilatation (30), mainly from the subendocardium to the subepicardium. Unlike exercise, dipyridamole is not associated with coronary spasm, a comparable increase in oxygen demand or the microcirculatory vasoconstriction produced by catecholamines. In the case of exercise stress, ischemic end points are therefore observed at lower levels of coronary flow that may not parallel the limitation of coronary flow observed after dipyridamole infusion at rest and without alpha-adrenergic stimulation by circulating catecholamines. Thus, the transient asynergy of contraction during dipyridamole echocardiography provides a pure measure of the hemodynamic severity of the coronary stenosis.

Clinical implications. In an appropriately selected patient group, simple variables obtained by means of on-line quantitative coronary angiography may allow the objective assessment of the severity of an isolated coronary artery stenosis during cardiac catheterization, thus providing invasive cardiologists with morphologic and physiologic data useful for direct diagnostic and therapeutic decision making and avoiding the need for intracoronary Doppler studies or a further noninvasive functional evaluation, such as dipyridamole echocardiography and stress thallium-201 perfusion imaging.

Our data suggest that in the presence of a positive dipyridamole echocardiographic response, stenotic flow reserve faithfully reflects the time to ischemia, as assumed by dipyridamole stress echocardiography. Furthermore, in the presence of a negative dipyridamole echocardiographic test, the same variable appears to be highly specific (90%) in predicting a normal test response.

The results of the present study cannot be extrapolated to patients with diffuse coronary artery disease, in whom angiographic measurements are of limited value (45), because the absence of a “normal” reference segment does not allow a reliable determination of percent stenosis or the other derived variables, such as stenotic flow reserve. In these patients, intracoronary Doppler measurements distal to the stenoses can provide information that cannot be obtained by quantitative coronary angiography.

Study limitations. 1) Our study group is small because of the strict inclusion criteria adopted for patient enrollment. 2) We evaluated the patients at an angiographic follow-up visit 6 months after successful coronary angioplasty; therefore, angiographic morphologic and hemodynamic consequences of primary lesions were not determined. However, these features should not alter the physiologic effect of coronary flow or the angiographic determination, although the presence of complex coronary artery lesion morphology could influence the diagnostic accuracy of dipyridamole echocardiography (46).

Conclusions. Angiographically derived stenotic flow reserve, as a single integrated measure of all the geometric characteristics of a stenosis, is the variable that best describes the functional significance of an isolated LAD lesion. Furthermore, in this selected group of patients with limited coronary artery disease, the angiographic variables of stenosis severity showed a better relation to the dipyridamole echocardiographic response than to the intracoronary Doppler variables.

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References


