

Indications for Cardiac Catheterization in the Diagnosis and Management of Coronary Artery Disease

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In 1979 coronary angiography remains the standard test for diagnosing the presence and extent of coronary artery disease. Non-invasive studies such as exercise testing are only relative predictors of coronary anatomy. Therefore, to define specifically whether or not coronary disease exists in a given patient and, if present, to delineate its location, severity and the potential for bypass surgery, a coronary angiogram is the test to obtain. The purpose of this paper is to discuss indications for coronary angiography in the management of patients with established or suspected coronary disease.

Figure 1 shows a schematic representation of the normal cardiac blood supply. The left and right coronaries exit directly from the aorta, and the left main coronary divides into two major branches, the left anterior descending and the circumflex vessels. It is important to note the extensive blood supply to the heart—mainly the left ventricle—through the left main coronary and its branches. Therefore, the left main coronary is frequently considered in a special class when discussing coronary artery disease. Other important vessels include the left anterior descending, the circumflex and the right coronary arteries. The term "single-," "double-," or "triple-vessel disease" refers to the number of these three important vessels involved with significant disease. Obstructive lesions of the coro-

naries represent the build-up of atherosclerotic material which decreases the vessel lumen and thereby decreases blood flow through the vessel. During coronary angiography, radiopaque dye is injected selectively into each coronary artery to allow visualization of each vessel and its major branches.

Figure 2 illustrates a single-frame cine from such a procedure; the significant atherosclerotic lesion is clearly demarcated. Therefore, using this technique, the extent and location of coronary artery lesions can be specifically identified.

Table 1 lists seven indications for coronary angiography. Considerable controversy continues to exist about the overall benefits of coronary bypass surgery and therefore it is extremely difficult to be unequivocal in listing one's indications for coronary angiography. However, the general guidelines given here are thought to be the most reasonable, although clinical circumstances must be carefully analyzed for each patient prior to proceeding to coronary angiography.

Symptomatic Indications

The first and probably most frequent indication for coronary angiography is failure of a patient to respond to reasonable medical management; the term "reasonable medical management" is used because of the wide response of patients to medical treatment. Some patients' response is less than ideal because of poor drug compliance while others have intoler-

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able side effects to the medications such as severe protracted headaches associated with nitrate administration, or significant fatigue or bad dreams associated with propranolol. In addition, a prior history of asthma or congestive heart failure is a contraindication for the use of propranolol. Finally, despite adequate medical management, some patients remain incapacitated because of their chest pain. In any situation in which a patient fails to get adequate symptomatic benefit from medical treatment and/or has significant side effects associated with the treatment, coronary angiography should be considered to determine if he or she is a candidate for coronary bypass surgery. Clearly 80% to 90% of patients have a significant reduction in symptoms and medication requirements following coronary bypass surgery and many of them remain symptom-free.¹ In a study of 100 patients randomly assigned to medical or surgical treatment, Mathur and Guinn² documented significantly improved treadmill performance for post-bypass surgery patients when compared with their medically treated counterparts. Furthermore, subsequent to treadmill testing, 70% of the surgical patients had no angina while only 20% of the medical

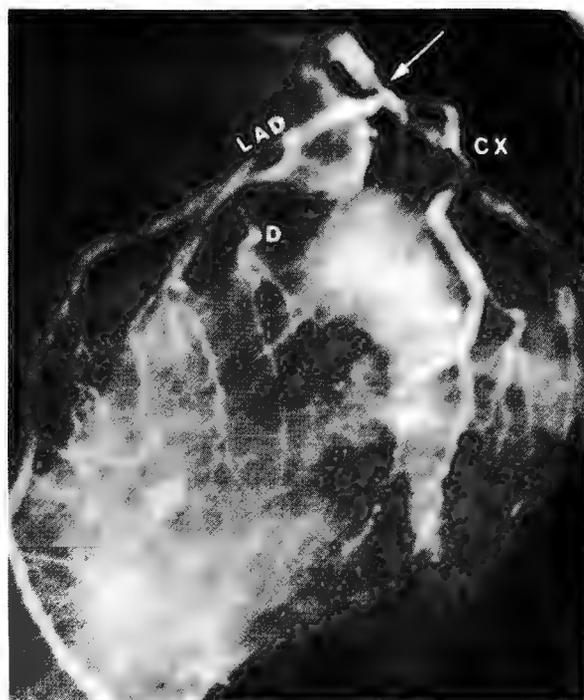


Fig 2—Left main coronary obstruction. The left coronary system seen in a lateral projection is filled with contrast medium during a contrast injection. Note critical left main artery stenosis (arrow).

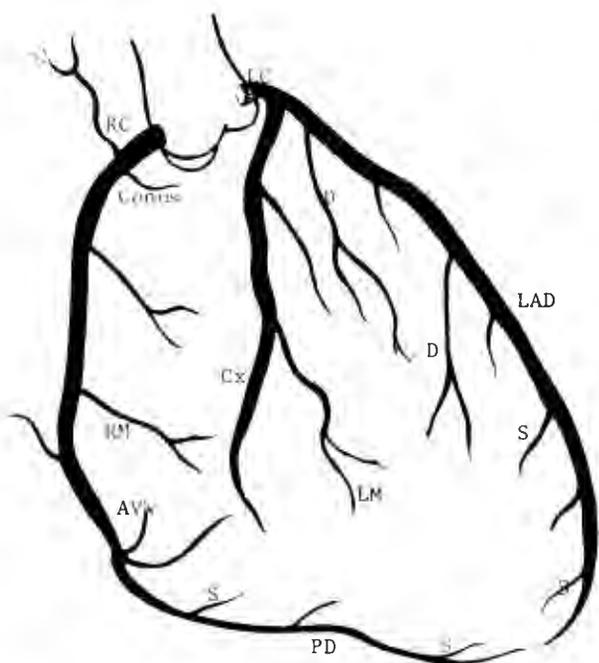


Fig 1—Schematic coronary anatomy. The right and left coronary arteries arise from the aorta. The short main left (LC) artery bifurcates into two large branches, the left anterior descending (LAD) artery and the circumflex (CX) artery supplying most of the anterior and lateral myocardial surface. The right coronary (RC) artery supplies the inferior myocardium through the posterior descending (PD) artery.

group were angina-free. These data emphasize the symptomatic benefits of coronary bypass surgery.

In addition to symptomatic benefits of coronary bypass surgery, certain subgroups of patients have improved longevity following this procedure. Ongoing studies will continue to better delineate these subgroups, but at present those patients with left main coronary artery disease appear to show improved function and prognosis as a result of the bypass operation. This fact is well illustrated by a three-year follow-up of the subgroup of patients with significant left main artery disease from the VA Cooperative Study.³ In this study, 12 (29%) of 41 medically treated patients died in the three-year follow-up compared to only 3 (7%) of 42 patients in the surgically treated group; the difference was significant ($p \leq 0.01$). In addition, the ben-

TABLE 1
Indications for Coronary Angiography

1. Angina inadequately responsive to reasonable medical management
2. Unstable angina
3. Atypical angina
4. "High-Risk" coronary patients
5. Undiagnosed chest pain
6. Heart failure post-myocardial infarction
7. Recurrent angina post-coronary bypass surgery

efit appeared to be greatest in those patients with associated right coronary disease.

Therefore, patients who do not respond well to reasonable medical treatment, and who are surgical candidates have an excellent prospect for improved functional status following bypass surgery. Furthermore, patients with left main vessel disease and perhaps yet-to-be-proven other subgroups have improved longevity following the bypass operation.

Unstable Angina Pectoris

A second major consideration for coronary angiography is patients who have unstable or rapidly worsening angina pectoris; in certain instances, these patients may even be classified as having pre-infarction angina. Most cardiologists feel that such patients should be stabilized first, if possible, with vigorous medical treatment. This philosophy is supported by studies suggesting that the risk of emergency coronary angiography and bypass surgery to patients with unstable angina is equal to the risk of initial medical management as far as morbidity and mortality are concerned⁴; however, patients who do not respond to medical treatment are candidates for angiography and coronary bypass surgery to relieve their persistent symptoms. For those patients who do respond to medical treatment the question then arises as to whether they should be catheterized and, if so, when. Generally, it seems prudent to consider angiography for young, active patients with unstable angina even though they respond to medical treatment, as a review of the angiographic and historical data will show.

Coronary angiography on large groups of patients who have had recent unstable angina have shown a 10% to 15% incidence of left main coronary disease.^{4,5} This finding is important because these patients have improved survival following bypass surgery. In addition, from 5% to 20% of patients may show normal coronary angiograms; variability of this number relates to the criteria used in any given study for the diagnosis of unstable angina. When accompanying electrocardiographic changes are required for the diagnosis of unstable angina, the incidence of normal coronaries associated with this chest pain syndrome is reduced. However, identifying normal coronaries is important as many patients are then found to have a non-cardiac cause for their chest pain. Rarely, indi-

viduals may have angina with normal coronaries, but generally these patients do well, with infrequent symptoms and a much lower risk of myocardial infarction than those patients with obstructive coronary disease. Therefore, the diagnosis of normal coronaries allows one to be much more positive in reassuring the patient about long-term survival. In addition to these subgroups, a majority of the remaining patients with unstable angina have significant three-vessel disease, a group that many feel may benefit from bypass surgery in terms of symptoms and prognosis.

One third or more of non-surgical patients who have unstable angina will have a subsequent unstable period within six months despite medical treatment.⁵ Excluding left main vessel disease, in randomized studies comparing medical versus surgical treatment for unstable angina, there was no significant difference in morbidity (subsequent myocardial infarctions) and mortality when the two groups were compared after four months or after 1½ years.⁶ However, these studies emphasize the improved functional performance seen in those patients who undergo surgery. Considering the higher incidence of left main vessel disease, the moderately frequent occurrence of normal coronaries and the significant subsequent disability of medically treated patients, coronary angiography is warranted in active individuals with unstable angina to better define the programs and appropriate treatment plan.

Atypical Angina Pectoris

A third consideration for coronary angiography is in those patients who demonstrate atypical or Prinzmetal type angina pectoris. This syndrome is characterized by chest pain at rest with associated significant ST-segment elevations which are transient in nature. These patients are often subject to significant rhythm disturbances and/or conduction abnormalities with the chest pain episodes.⁷ Anatomically, patients with atypical angina may have either high-grade fixed obstructive lesions or normal coronaries with intermittent vessel spasm producing the symptoms. These patients are frequently difficult to manage medically, thus the distinction between significant obstructive disease and spasm is important from the standpoint of therapeutic options, as patients with significant obstructive disease generally benefit from by-

pass surgery whereas patients with spasm do not.

High-Risk Patients

Symptoms of angina do not correlate well with the extent of disease. Ideally, one would like to have a simple noninvasive test that would identify those patients who have significant left main vessel disease which derives so much prognostic benefit from bypass surgery, but no such test is available. However, certain exercise test responses are considered suggestive of severe coronary artery disease which frequently includes left main vessel disease. Table 2 lists those high-risk abnormalities. Included in this group⁹ are patients who develop marked (2 mm or greater) ST-segment depression with exercise testing, particularly at low levels of exercise performance. In addition, the development of ST-segment elevation on treadmill testing in an area of the electrocardiogram not showing a prior myocardial infarction is a significant predictor of severe proximal coronary disease if not of left main vessel disease.⁹ Finally, patients who develop hypotension at nonmaximal exercise performance are again likely to have significant disease.¹⁰ Such hypotension suggests severe myocardial ischemia consistent with marked proximal coronary artery disease. In these high-risk patients coronary angiography is important to delineate this anatomic abnormality.

Other high-risk patients include those who have a history of prior myocardial infarction and significant symptomatology and/or poor exercise test responses, particularly if they are in the high-risk category listed above. Furthermore, subendocardial myocardial infarctions may represent another significant risk group. Fifty consecutive patients with a recent condition of this type at the Mayo Clinic¹¹ showed a high frequency of symptomatic disability in a short-term ten-month follow-up. Fifteen patients (30%) had significant stable angina pectoris and nearly half, 23 (46%) of 50, developed unstable angina over the short time of the study; only 12 (24%) of the 50 remained angina-free. Considering the frequency of significantly limiting symptomatology in this study, early angiography in patients with a recent subendocardial myocardial infarction seems warranted to identify those patients who are candidates for bypass surgery, particularly in physically active individuals.

TABLE 2
Exercise Test Predictors of Potentially Severe Coronary Disease

1. Marked ST-segment depression
2. ST-segment elevation in an area of noninfarction of the ECG
3. Hypotension at nonmaximal performance

Chest Pain Diagnosis

To this point, the discussion has centered on the diagnosis of the extent of coronary disease. Another consideration for coronary angiography is specifically to exclude the existence of coronary disease. Not every patient with vague, intermittent or poorly defined chest discomfort is a candidate for a coronary angiogram; however, there are those in whom noninvasive studies, including exercise testing and perhaps thallium imaging, fail to demonstrate clearly whether or not coronary artery disease exists. Most of these patients have symptom complexes with components that are both typical and atypical of angina. In addition, the concern about the possibility of coronary disease may be limiting these patients' lifestyles. In such instances, coronary angiography is warranted to provide a definitive diagnosis.

Congestive Heart Failure

Congestive heart failure after a myocardial infarction can be a difficult management problem, particularly if it does not respond to routine medical treatment for heart failure. Left heart failure may be manifested either as a congested state with recurrent pulmonary edema and shortness of breath or as a low-output state in which the patient's major complaints relate to low forward cardiac output, that is, fatigue, weakness and exercise intolerance without chest pain. Clinical findings frequently include either a mitral regurgitation murmur, ventricular gallop rhythms and/or a contour on apex palpation, suggesting a left ventricular aneurysm. Anatomically, one wishes to know whether or not there is a localized aneurysm or significant mitral regurgitation. Cardiac catheterization of patients who fail to respond to routine treatment will delineate the severity and location of left ventricular wall motion abnormalities as well as whether or not there is significant valvular insufficiency. In addition, coronary angiograms identify obstructive vessels which may exist in the areas of remaining functional myocardium.

Patients with severe diffuse non-localized left ventricular dysfunction are generally not candidates for bypass surgery, because in such instances the operative risk is increased and there is no benefit in terms of reducing heart failure. However, if a localized, correctable mechanical problem exists such as a left ventricular aneurysm or significant mitral regurgitation, the condition of these patients may be significantly improved by surgical correction of the appropriate defect with or without additional bypass surgery as dictated by the coronary anatomy.

Recurrent Angina Pectoris Post-Bypass Surgery

Finally, those patients who have previously undergone bypass surgery and who developed recurrent angina pectoris may need angiography; as the frequency of bypass surgery increases, so will the numbers of such patients. Two factors determine the need for repeat coronary post-bypass angiography. First, if the recurrent angina occurs within one to two months following bypass surgery, it is likely that one or more vein bypass grafts have occluded.¹² In this event the preoperative angiograms should be reviewed and the anatomy discussed with the surgeon. If the distal vessels suggest poor distal runoff either angiographically and/or at the time of surgery and the post-bypass flows were poor, it is unlikely that reoperation will carry any better chance of maintaining a patent graft, and consideration of repeat catheterization should be postponed unless medical treatment fails to be effective. Conversely, if flows were good at the time of surgery and the distal runoff appeared adequate, graft failure might be caused by a technical problem resulting from surgery. Reoperation could conceivably benefit such a patient, thus a repeat angiogram is warranted; however, early recurrent angina is most often seen in patients with severe distal disease.

A further consideration for angiography is the patient who has experienced marked symptomatic improvement for a long time following the bypass operation. When recurrent angina occurs in such a patient, the anatomic problem is generally not in the graft but represents progression of the disease in the native circulation, either distal to the graft insertion or in other non-graftable vessels. Depending on the symptomatology and the state of the other vessels at the

time of surgery, it is reasonable to consider a repeat study in these patients, looking for other potentially graftable vessels.

The foregoing discussion should provide a reasonable approach to the utilization of cardiac catheterization and coronary angiographic techniques in the diagnosis and management of patients with coronary artery disease. Combining the functional performance information derived from noninvasive tests with the anatomic abnormalities demonstrated with coronary angiography provides the most thorough evaluation of patients with coronary disease. The information derived from coronary angiography is frequently important in the prognostic and therapeutic decisions regarding patients with coronary disease.

Figures 1 and 2 are reproduced with permission from B Soto, RO Russell, RE Moraski: *Radiographic Anatomy of the Coronary Arteries: An Atlas*. Mount Kisco (New York), Futura Publishing Company, Inc., 1976.

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