



# Angioplasty Versus Bypass Surgery for Coronary Artery Disease

Andrew D. Michaels, MD; Kanu Chatterjee, MB, FRCP



## What Is Coronary Artery Disease?

Coronary artery disease (CAD) is a disease caused by “hardening” (termed atherosclerosis) of the coronary arteries on the surface of the heart (Figure 1). CAD is the leading cause of death for both men and women in the United States.

The inside walls of arteries are normally smooth and flexible, allowing blood to flow through them easily. Fatty deposits, or plaques, may build up inside the arterial wall. These plaques narrow the artery and can reduce or even completely stop the flow of blood.

## What Are the Symptoms of Coronary Artery Disease?

When blood flow is reduced in the coronary arteries, patients may develop angina. Angina is a discomfort in the chest, arms, or lower jaw that occurs when insufficient blood flows to the heart muscle. Angina typically develops during physical exertion or emotional stress, when the heart muscle needs more oxygen and is working harder. Angina usually lasts several minutes, and goes away with rest.

Patients with coronary atherosclerosis are at risk for suffering a heart attack. A heart attack can occur when a coronary artery becomes blocked, usually by a blood clot. The region of the heart muscle fed by the blocked artery loses its ability to function and eventually turns into scar tissue. Unlike anginal pain, the pain from a heart attack usually lasts more than 20 minutes and does not go away with rest.

## How Is Coronary Artery Disease Diagnosed?

Your physician will obtain a medical history and perform a complete physical examination. An electrocardiogram (ECG) may show evidence of coronary artery blood flow insufficiency (ischemia) or a heart attack. Your doctor may order a noninvasive exercise treadmill stress test or a pharmacological stress test that does not require exercise. These tests may show evidence of ischemia on the ECG.

The optimum method for diagnosing CAD is by coronary angiography (also called cardiac catheterization). This test is performed under local anesthesia and involves injecting x-ray dye (contrast medium) into the coro-

nary arteries via tubes (catheters) while an x-ray camera makes a film of the blood flow pattern that shows the exact location and severity of the coronary artery narrowings.

## How Is Coronary Artery Disease Treated?

The findings from coronary angiography guide the strategy for the best treatment. The options of medical therapy, angioplasty and stenting, or coronary artery bypass surgery depend largely on the severity of disease. In general, patients with coronary narrowings that do not limit coronary artery blood flow receive medications and lifestyle modification to help prevent progression. If a patient has coronary atherosclerosis that limits blood flow in the coronary arteries, balloon angioplasty and stenting can be offered. In patients with multiple areas of coronary artery narrowing or blockage, coronary artery bypass graft surgery is generally recommended.

## Medications and Lifestyle Modifications

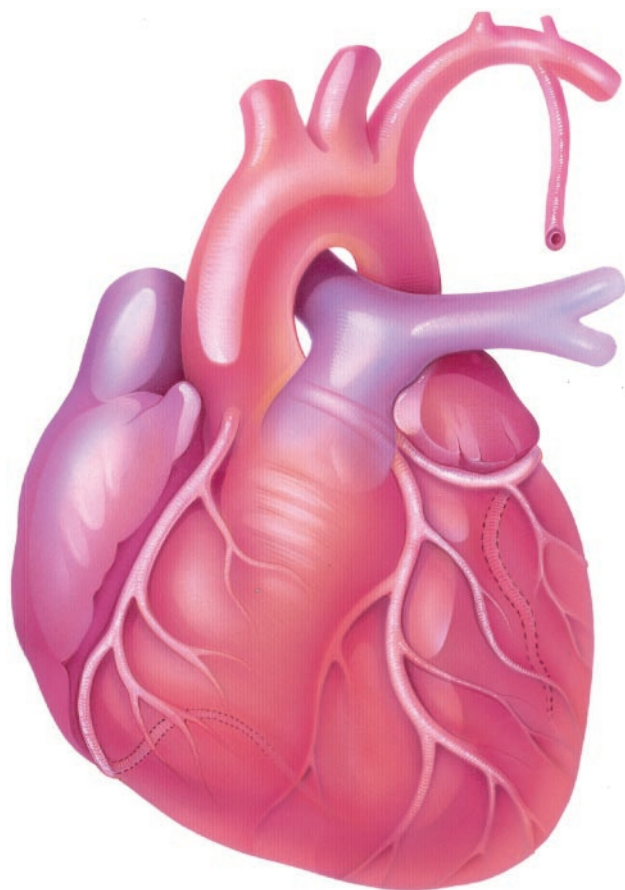
Medications are prescribed to reduce the risk of death by reducing the risk of heart attack, stroke, and heart failure.

From the Division of Cardiology, Department of Medicine, University of California at San Francisco Medical Center, San Francisco.  
Correspondence to: Kanu Chatterjee, MB, FRCP, Professor of Medicine, Lucie Stern Professor of Cardiology, Chatterjee Center for Cardiac Research, University of California, San Francisco, 505 Parnassus Ave, San Francisco, CA 94143. E-mail [chatterj@medicine.ucsf.edu](mailto:chatterj@medicine.ucsf.edu)  
(*Circulation*. 2002;106:e187-e190.)

© 2002 American Heart Association, Inc.

*Circulation* is available at <http://www.circulationaha.org>

DOI: 10.1161/01.CIR.0000040586.24302.B9



**Figure 1.** Normal coronary artery anatomy. The heart's left ventricle pumps blood to the aorta, the body's main artery. At the beginning of the aorta, the left and right coronary arteries emerge. The coronary arteries travel on the outer surface of the heart and divide into smaller branches that penetrate into the heart muscle. Reprinted with permission ©2000 StayWell – www.krames.com.

Antianginal medications (such as  $\beta$ -blockers, nitroglycerin, and calcium channel blockers) reduce the symptoms of angina by reducing the amount of oxygen the heart requires and/or increasing the amount of blood flow through the arteries. Medications that reduce the risk of death are aspirin or aspirin-like drugs, cholesterol-lowering drugs, and agents such as  $\beta$ -blockers and angiotensin-converting enzyme inhibitors that block the harmful effects of some hormones.

Lifestyle changes help prevent the continuing build-up of fatty deposits in the coronary arteries. These changes include smoking cessation, a diet low in fat and cholesterol, weight loss, regular exercise, stress management, diabetes control, and blood pressure

control. These medications and lifestyle changes are equally important for those patients who also undergo coronary revascularization with angioplasty, stenting, or bypass surgery.

### Angioplasty and Stenting

Roughly one-third of patients with CAD will undergo coronary angioplasty and stenting. These procedures take place in a cardiac catheterization laboratory, using the same type of catheter used for diagnostic coronary angiography. During balloon angioplasty, a balloon-tipped catheter pushes plaque back against the arterial wall to allow for improved blood flow in the artery. Another angioplasty technique involves devices that remove plaque from the arteries by cutting it

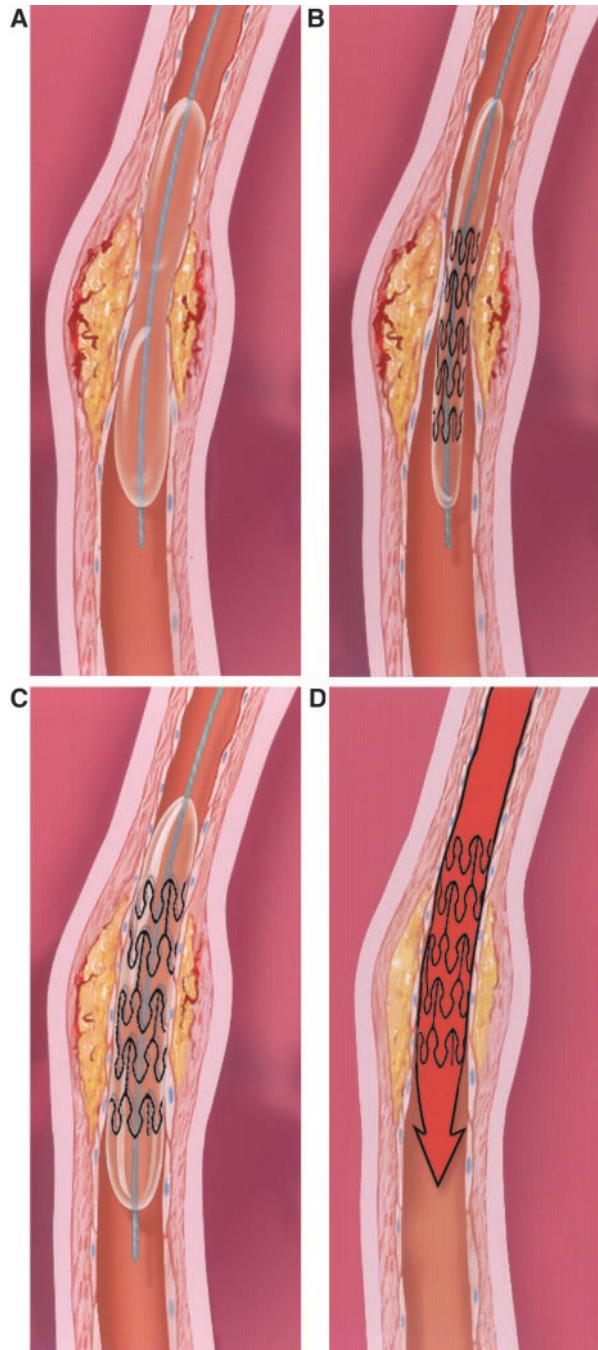
away. Coronary stenting often accompanies the angioplasty procedure. Stents are small wire-mesh metal tubes that provide scaffolding to support the damaged arterial wall (Figure 2), reducing the chance that the vessel will close again (restenosis) after angioplasty. (For more information on restenosis see Dangas G, Kuepper F. Restenosis: repeat narrowing of a coronary artery: prevention and treatment. *Cardiology Patient Page. Circulation.* 2002;105:2586–2587).

Nearly one million balloon angioplasty procedures are performed each year in the United States alone. Appealing to patients and physicians alike is the relative low risk of this nonsurgical treatment. Balloon angioplasty takes 1 to 2 hours to complete and is done with local anesthesia on patients who are mildly sedated. Blood thinners, called glycoprotein IIb/IIIa inhibitors, may be used intravenously during the angioplasty to prevent intracoronary blood clotting. Most patients will stay overnight in the hospital for observation, will be discharged the following morning, and can resume normal activities within a week. Patients who receive a coronary stent will be treated with a blood thinner (typically clopidogrel) for 1 month in addition to long-term aspirin to prevent a blood clot from developing on the stent.

Some patients have coronary plaques that are not amenable to balloon angioplasty or stenting because 1) the coronary artery is too small or 2) there is a complete blockage that cannot be crossed with the balloon.

### Coronary Artery Bypass Surgery

Of those patients with coronary artery disease, about 10% will undergo coronary artery bypass graft (CABG) surgery. Patients with severe narrowing or blockage of the left main coronary artery or those with disease involving two or three coronary arteries are generally considered for bypass surgery. In patients with very small coronary



**Figure 2.** Balloon angioplasty and stenting. A balloon-tipped catheter is positioned in the coronary artery narrowing and inflated (A). The stent is positioned at the site of the coronary narrowing (B). When the balloon is inflated, the stent expands and presses against the arterial wall (C). The balloon is deflated and removed. The stent remains permanently in place, helping to keep the artery open (D). Within a few weeks, new tissue will grow over the stent struts and cover it. Reprinted with permission ©2000 StayWell – www.krames.com.

how many coronary arteries (and their main branches) are blocked, patients typically receive 1 to 5 bypasses. The most commonly used bypass vessels are the saphenous vein from the leg, the internal mammary artery from the chest, and the radial artery from the arm. During a CABG, a heart-lung machine artificially maintains circulation while the surgeon operates on the heart. CABG operations require general anesthesia and typically 4 to 7 days in the hospital. It may take up to 3 months to fully recover from the surgery.

### Deciding Between Angioplasty and Bypass Surgery

The choice of angioplasty or bypass surgery is based on physician and patient preference, as well as patient-specific characteristics, such as diabetes or heart failure, which may favor one strategy over another. Angioplasty should be considered when one, two, or even three arteries have become narrowed, provided that the arteries are suitable for angioplasty. When there is significant narrowing of the left main coronary artery or of all three major coronary arteries, CABG should be considered. CABG is preferable in the presence of diabetes and/or heart failure when two or three coronary arteries are narrowed. If revascularization is feasible, either angioplasty or CABG is indicated when medical treatment has failed to relieve angina.

### Newer Developments for Coronary Stents

The main limitation of coronary balloon angioplasty and stenting is restenosis, when the treated artery becomes narrowed again. The chance of restenosis is 40% with balloon angioplasty alone. Stent implantation reduces the chance of restenosis to 25%. When restenosis occurs after stent use, physicians call this “in-stent restenosis.”

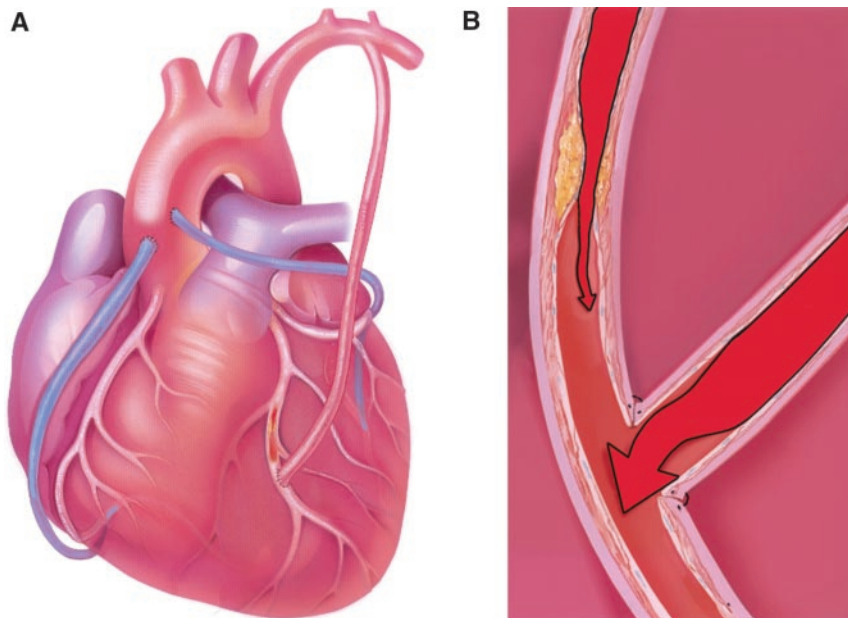
Intracoronary radiation (brachytherapy) is the most effective treatment for in-stent restenosis. This procedure involves balloon angioplasty of the re-

arteries, the surgeon may be unable to operate.

In a CABG, the surgeon uses a portion of a healthy vessel (either an

artery or vein) from the leg, chest, or arm to create a detour or bypass around the blocked portion of the coronary artery (Figure 3). Depending on





**Figure 3.** Coronary artery bypass grafts. The cardiac surgeon may use a vein removed from the leg and/or an artery from inside the chest wall (A) to provide a new path for blood flow from the aorta to the heart muscle (B). Reprinted with permission ©2000 StayWell – www.krames.com.

nosed coronary segment, followed by use of an irradiated catheter for several minutes. The irradiated coronary tissue is less likely to grow within the stent, reducing the risk of restenosis.

Over the past 2 years, a new generation of drug-eluting stents seems to be a breakthrough in the prevention of in-stent restenosis. These stents are coated with a special medication that prevents scar tissue growth in the artery where the stent is placed, significantly reducing the risk of in-stent restenosis.

### Newer Developments for Bypass Surgery

The minimally invasive direct coronary artery bypass (MIDCAB) tech-

nique is a less invasive version of the traditional CABG. The MIDCAB approach does not require the use of a heart-lung machine and does not require the surgeon to cut through the breastbone (sternum). Instead, the surgeon makes a small incision between the ribs to operate on the blocked artery. Unlike the traditional CABG operation, the MIDCAB approach is performed on the beating heart with the use of a stabilizing device. Although the MIDCAB is less traumatic, usually involves a shorter hospital stay (average 3 days) and recovery period, and requires smaller incisions, this technique generally cannot be used when there are more than two blocked arteries.

### Additional Information

- American Heart Association home page. Available at <http://www.americanheart.org>. Accessed October 30, 2002.
- HeartCenterOnline. Available at <http://www.heartcenteronline.com>. Accessed October 30, 2002.
- Clinsights, Inc. TCTMD. Available at <http://www.tctmd.com>. Accessed October 30, 2002.
- Gibbons RJ, Chatterjee K, Daley J, et al. ACC/AHA/ACP-ASIM guidelines for the management of patients with chronic stable angina: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on the Management of Patients With Chronic Stable Angina). *J Am Coll Cardiol*. 1999;33:2092-2197.
- Graham MM, Ghali WA, Faris PD, et al. Survival after coronary revascularization in the elderly. *Circulation*. 2002;105:2378-2384.
- Dzavik V, Ghali WA, Norris C, et al. Long-term survival in 11,661 patients with multivessel coronary artery disease in the era of stenting: a report from the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) Investigators. *Am Heart J*. 2001;142:119-126.
- Morrison DA, Sethi G, Sacks J, et al. Percutaneous coronary intervention versus coronary artery bypass graft surgery for patients with medically refractory myocardial ischemia and risk factors for adverse outcomes with bypass: a multicenter, randomized trial. Investigators of the Department of Veterans Affairs Cooperative Study #385, the Angina With Extremely Serious Operative Mortality Evaluation (AWESOME). *J Am Coll Cardiol*. 2001;38:143-149.
- King SB III, Kosinski AS, Guyton RA, et al. Eight-year mortality in the Emory Angioplasty versus Surgery Trial (EAST). *J Am Coll Cardiol*. 2000;35:1116-1121.
- Berger PB, Velianou JL, Aslanidou Vlachos H, et al. Survival following coronary angioplasty versus coronary artery bypass surgery in anatomic subsets in which coronary artery bypass surgery improves survival compared with medical therapy: results from the Bypass Angioplasty Revascularization Investigation (BARI). *J Am Coll Cardiol*. 2001;38:1440-1449.