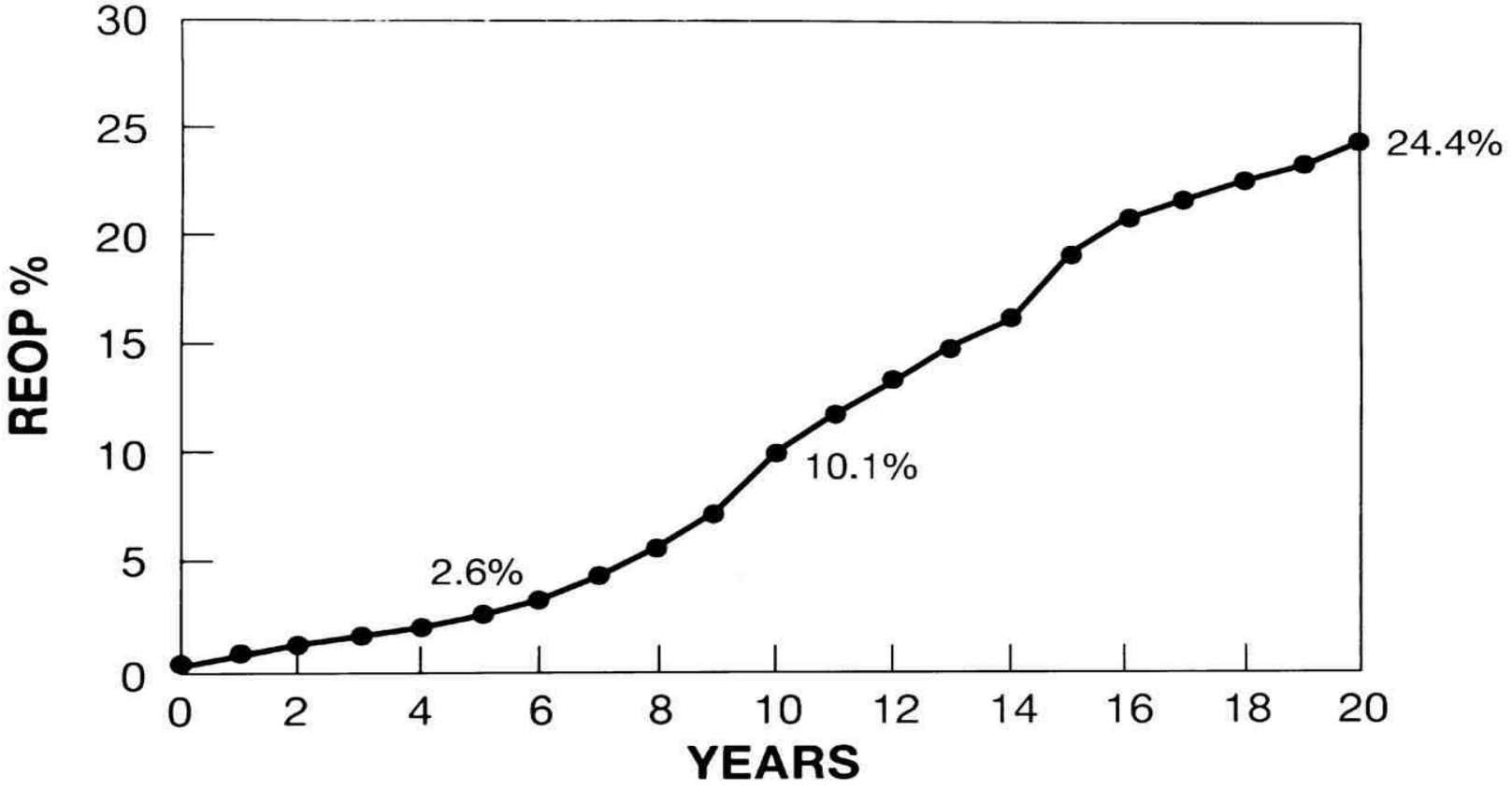
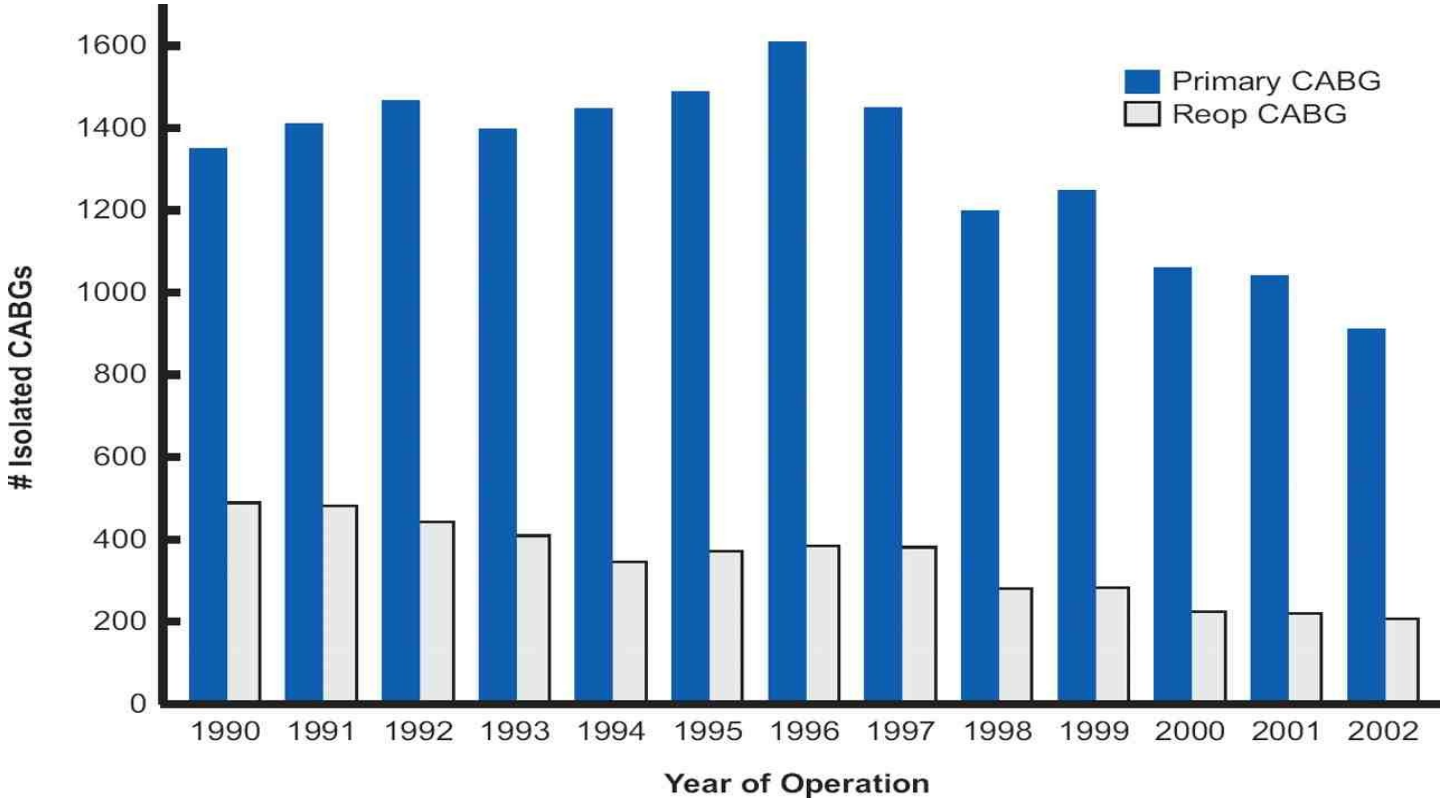
Cardiac reoperation considerations

2008

Incidence

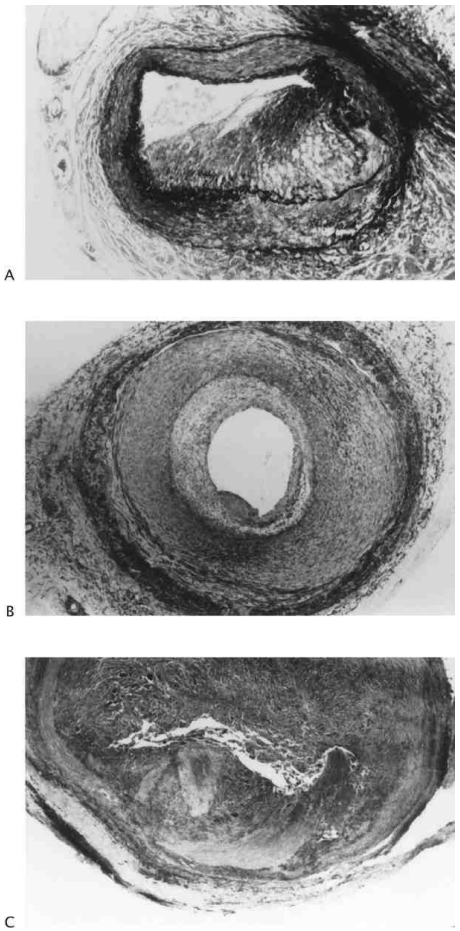


Study of 4000 patients who underwent bypass surgery from 1971 to 1974 showed that 25% of patients had undergone a reoperation within a period of 20 years after primary operation. (*Data from Cosgrove DM, Loop FD, Lytle BW, et al: Predictors of reoperation after myocardial revascularization. J Thorac Cardiovasc Surg 1986; 92:811.*)



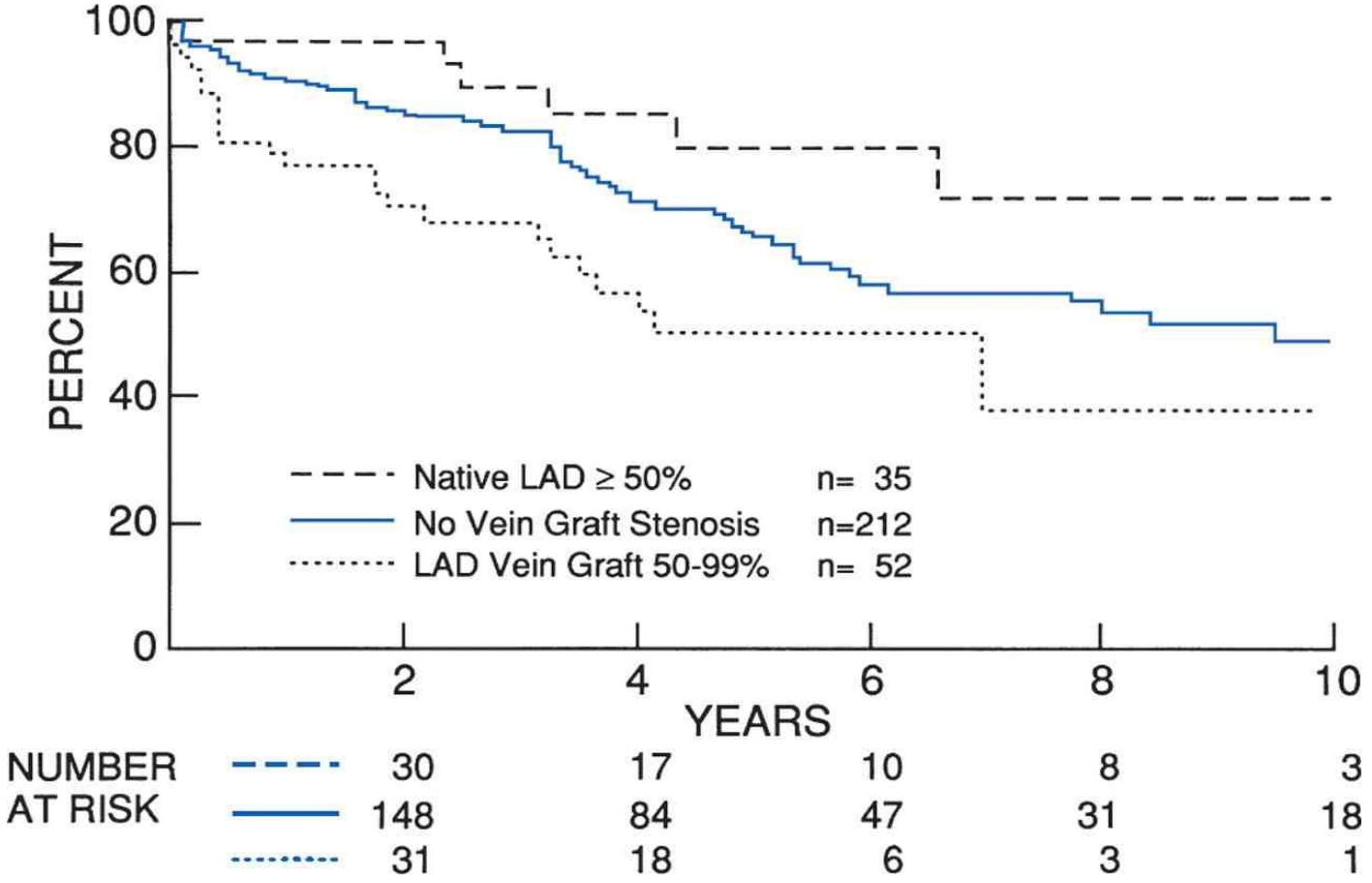
Study of 21,568 patients who underwent bypass surgery from 1990 to 2003 showed a steady decrease in the number of patients undergoing redo coronary artery operations. (*Data from Sabik JF, Blacksotne EH, Houghtaling PL, et al: Is reoperation still a risk factor in coronary artery bypass surgery? Ann Thorac Surg 2005; 80:1719.*)

Graft failure



Pathology of (A) native coronary artery atherosclerosis, (B) vein graft intimal fibrosis, and (C) severe vein graft atherosclerosis. (*Lytle BW, Cosgrove DM: Coronary artery bypass surgery, in Wells SA (ed): Current Problems in Surgery. Philadelphia, Saunders, 1992; p 733.*)

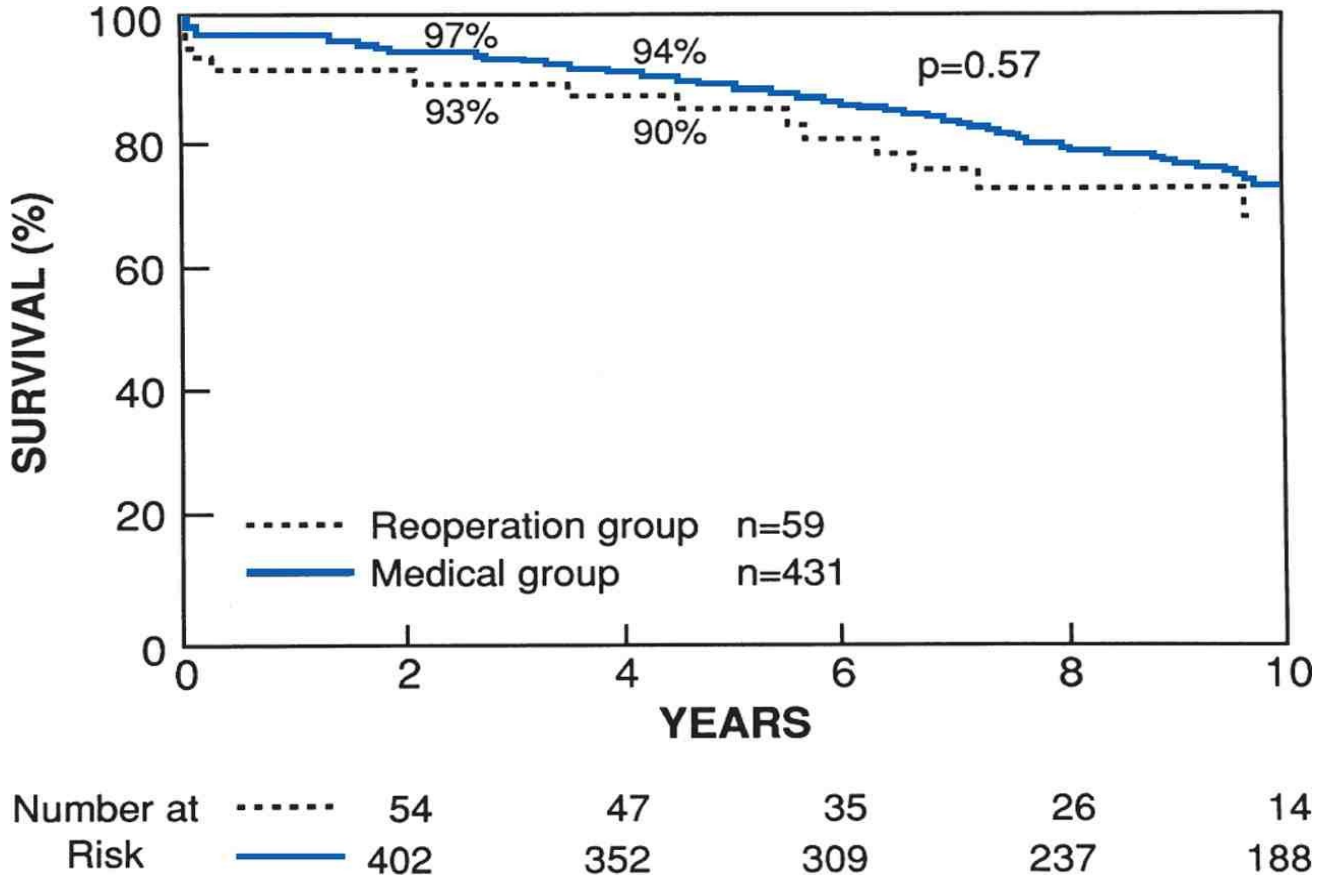
LSV grafts



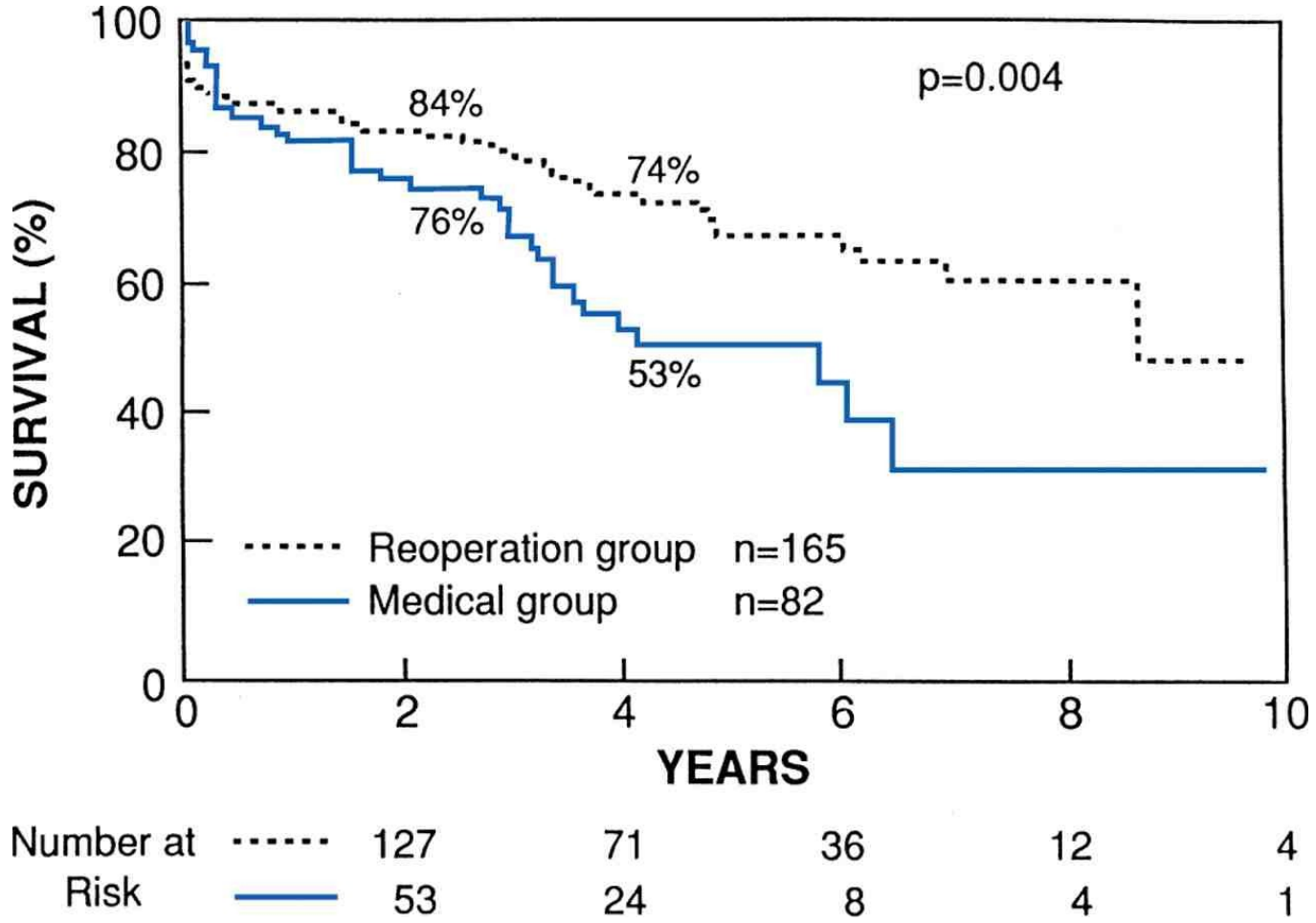
Lytle BW, Loop FD, Taylor PC, et al: Vein graft disease: The clinical impact of stenoses in saphenous vein bypass grafts to coronary arteries. J Thorac Cardiovasc Surg 1992; 103:831.)

Indications

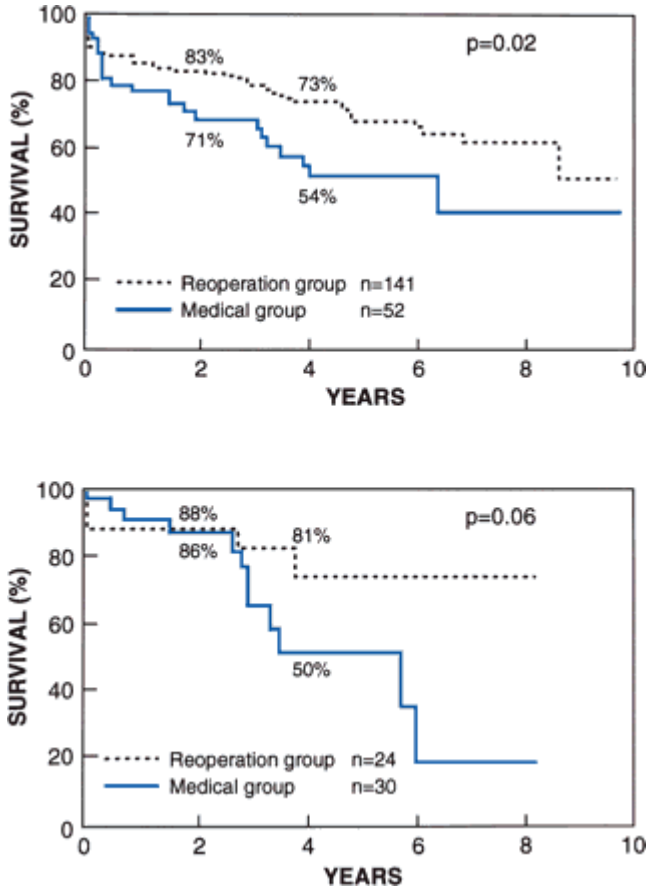
- no randomized trials of medical versus surgical management pertain to patients with prior surgery.
- The coronary pathology of patients with previous bypass surgery is different from that of patients with only native-vessel stenoses, and we cannot assume that the natural history of, for example, triple-vessel disease based on atherosclerotic vein grafts is equivalent to that of triple-native-vessel disease.



The survival of patients with early (<5 years after operation) stenoses in vein grafts was favorable with and without reoperation (*p* = NS). *(Lytle BW, Loop FD, Taylor AC, et al: The effect of coronary reoperation on the survival of patients with stenoses in saphenous vein to coronary bypass grafts. J Thorac Cardiovasc Surg 1993; 105:605.)*



If patients had late (5 years after operation) stenoses in LAD vein grafts, they had a better survival rate (p = .004) with immediate reoperation than if they received initial nonoperative treatment. (*Lytle BW, Loop FD, Taylor AC, et al: The effect of coronary reoperation on the survival of patients with stenoses in saphenous vein to coronary bypass grafts. J Thorac Cardiovasc Surg 1993; 105:605.*)



- Patients with late stenoses in LAD vein grafts (*top*) had immediate improvement in their survival rate. Patients with moderate (20 to 49%) stenoses in LAD vein grafts had equivalent survival with or without reoperation for approximately 2 years, but after that point, the patients who did not have reoperation did poorly. (*Lytle BW, Loop FD, Taylor PC, et al: The effect of coronary reoperation on the survival of patients with stenoses in saphenous vein to coronary bypass grafts. J Thorac Cardiovasc Surg 1993; 105:605.*)

Anatomic indications

- atherosclerotic (late) stenoses in vein grafts that supply the LAD artery,
- multiple stenotic vein grafts that supply large areas of myocardium, and
- multivessel disease with a proximal LAD lesion and/or abnormal LVF based on either native-vessel lesions or stenotic vein grafts or a combination of the two pathologies.

TECHNICAL ASPECTS

1. Sternal reentry
2. Stenotic or patent vein or arterial bypass grafts
3. Aortic atherosclerosis
4. Diffuse native-vessel coronary artery disease
5. Coronary arteries located amid old grafts and epicardial scarring
6. Lack of bypass conduits

Perioperative MI

These anatomic causes of perioperative myocardial infarction include:

- injury to bypass grafts,
- atherosclerotic embolization from vein grafts or the aorta to distal coronary arteries,
- myocardial devascularization secondary to graft removal,
- hypoperfusion through new grafts,
- failure to deliver cardioplegic solution,
- early vein graft thrombosis,
- incomplete revascularization,
- diffuse air embolization, and
- technical error.

To be consistently successful, coronary reoperations must be designed to avoid these causes of myocardial infarction.

Preoperative Assessment

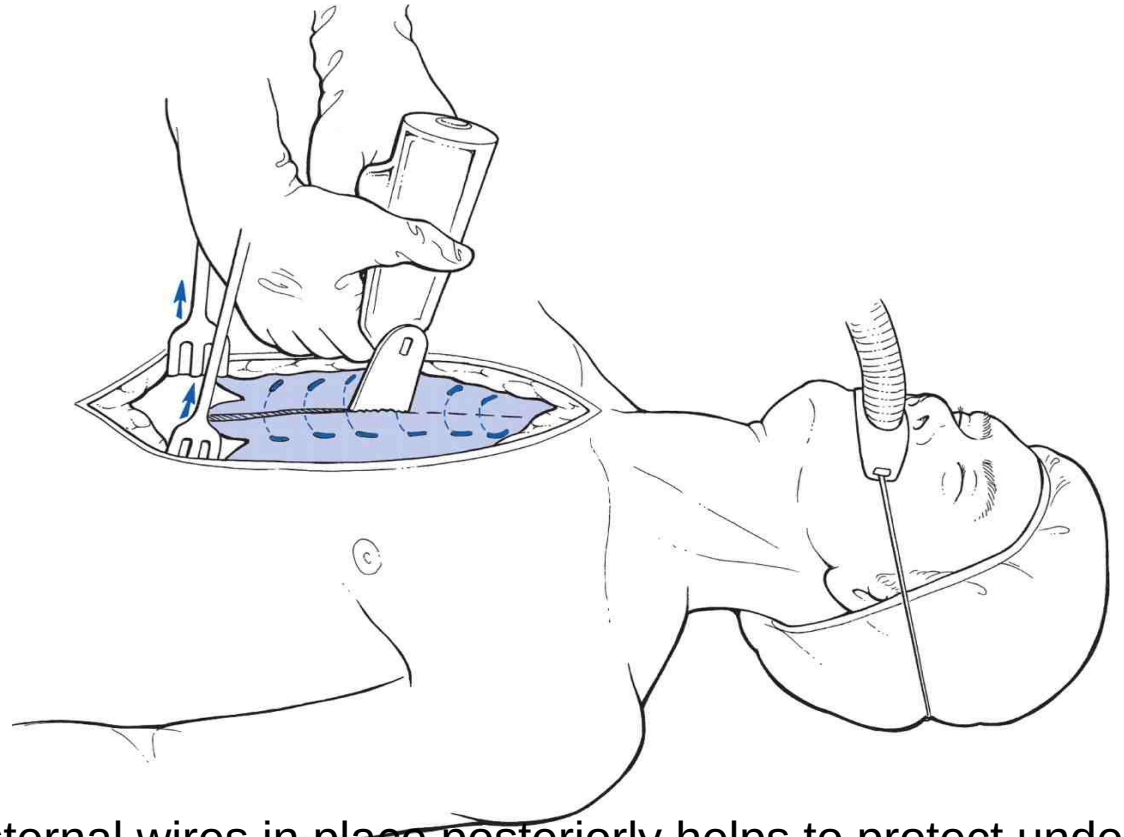
- native coronary and bypass graft anatomy
- Myocardial scar and viability differentiation
  - thallium scanning, positron emission tomography, and stress (exercise or dobutamine) echocardiography
- plan for bypass conduit selection
  - ITA angiography often is helpful.
  - Venous Doppler studies can be used to assess the presence of greater and lesser saphenous vein segments, and
  - arterial Doppler studies can assess the radial and inferior epigastric arteries and establish the adequacy of flow to the digits during radial artery occlusion.

Median Sternotomy Incision

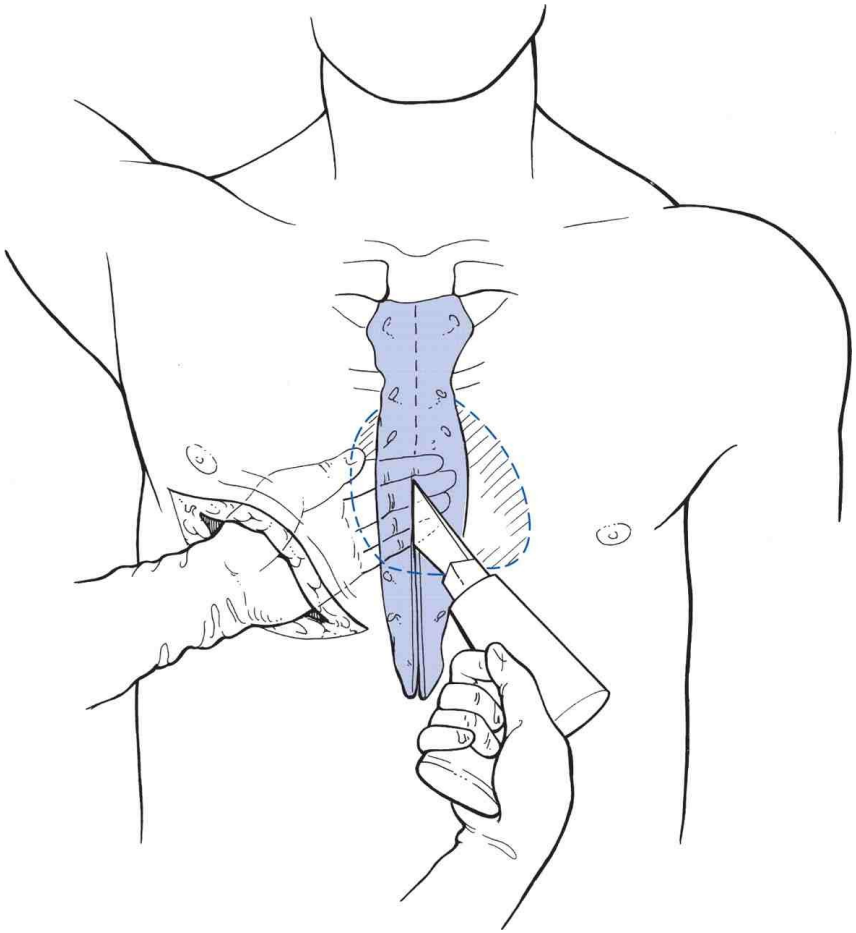
Situations associated with increased risk during a repeat median sternotomy include:

- right ventricular or aortic enlargement,
- a patent vein graft to the right coronary artery,
- an in situ right ITA graft patent to a left coronary artery branch,
- an in situ left ITA graft that curls under the sternum,
- multiple previous operations, and
- difficulty reopening the sternum during a previous reoperation.

In such situations, vessels for arterial (via the femoral or axillary artery) and venous access for cardiopulmonary bypass are dissected out prior to sternal reentry. All bypass grafts except for the internal thoracic arteries may be prepared prior to sternal reentry.



Leaving the sternal wires in place posteriorly helps to protect underlying structures while the posterior table of the sternum is divided with an oscillating saw. The direction of retraction with rake retractors should be anterior, not lateral.

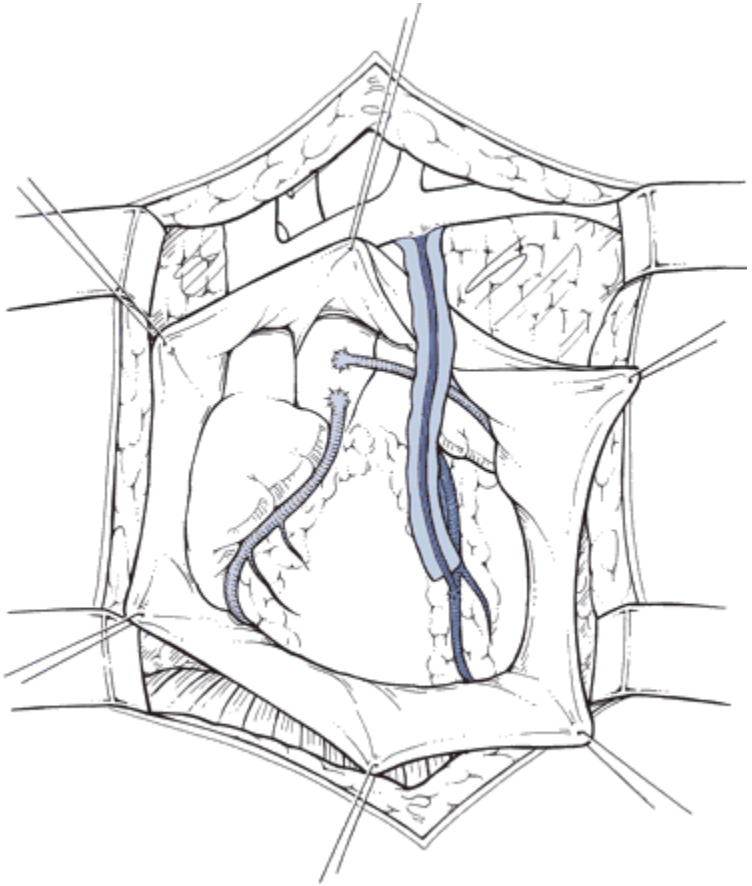


- A small anterolateral right thoracotomy allows dissection of substernal structures such as patent grafts and the right ventricle or aorta away from the sternum under direct vision. While the sternum is being divided, the surgeon may place a hand behind the sternum for further safety.

- Another technique for sternal reentry in high-risk patients is to heparinize, cannulate, and initiate cardiopulmonary bypass prior to median sternotomy.
- Advantages: the heart can be emptied and allowed to fall away from the sternum, and cardiopulmonary bypass already has been initiated for protection if an injury does occur.
- Disadvantages: extensive mediastinal dissection must be carried out in a heparinized patient, including dissection of the right internal thoracic artery if that is to be used.

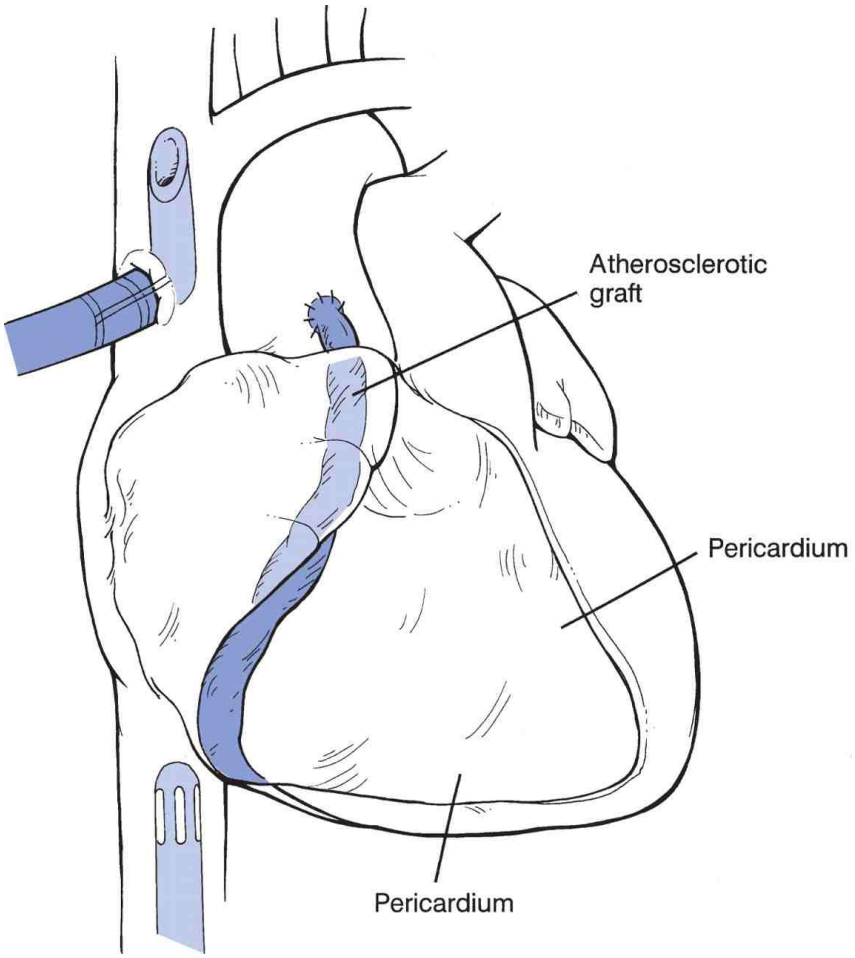
- Once the sternum has been divided, the pleural cavities are entered.
- A general principle of dissection during reoperation is that starting at the level of the diaphragm and proceeding in a cranial direction is usually the safest approach. At the level of the diaphragm, few critical structures are injured if the wrong plane is entered.
- The innominate vein is dissected away from both sides of the sternum with scissors, a maneuver that prevents a "stretch" injury to that vein.
- Once the right side of the sternum is separated from the cardiac structures, it is usually possible to prepare a right ITA graft. Because of parietal pleural thickening, it is often more difficult to obtain length on ITA grafts during reoperation than it is during primary procedures, and the right ITA frequently is used as a "free" graft. Once the right ITA dissection is completed to the superior border of the first rib, an incision is made in the parietal pleura to separate the proximal ITA from the area of the phrenic nerve. Thus, if the right ITA needs to be converted to a "free" graft during aortic cross-clamping, it makes division at that point easier because the proximal ITA is clearly identifiable.

- Although intrapericardial dissection of the left side of the heart is left until later, freeing the left side of the anterior chest wall from the underlying structures (which may include a patent ITA graft) is undertaken now. This is difficult only if there is a patent ITA graft that is densely adherent to the chest wall. Again, it is best to enter the left pleural cavity at the level of the diaphragm and proceed in a cranial direction.
- The most difficult point of dissection is usually at the level of the sternal angle, where a patent ITA graft may approach the midline and be adherent to the sternum or to the aorta.
- There are no tricks for dissecting out a patent ITA graft except for being careful.
- The danger to a patent left ITA graft during sternal reentry and mediastinal dissection is entirely related to the location of the graft at the time of the primary operation.



- A patent left ITA-to-LAD graft should not pose a threat during reoperation. At a primary operation, the pericardium should be divided in a posterior direction, and the ITA graft should be placed in that incision. The ITA graft then will lie posterior to the lung and will not be pushed toward the midline by the lung or become adherent to the sternum.

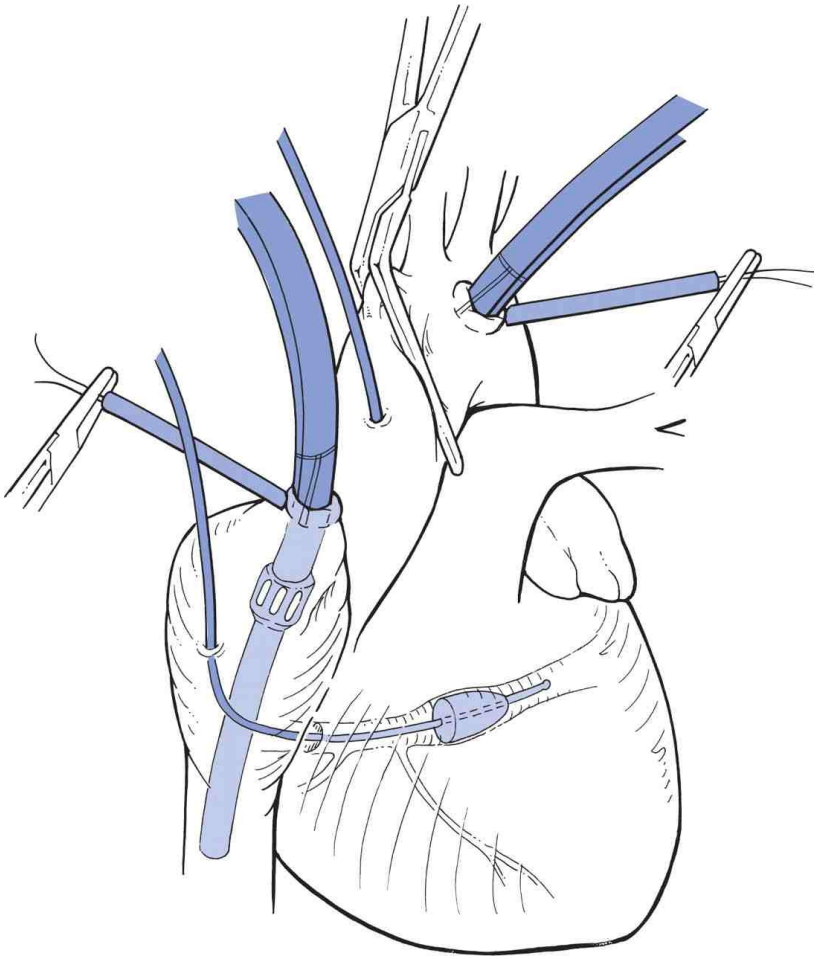
- Once the left side of the chest wall is free, the left IMA is prepared (if it has not been used at a previous operation),
- the sternal spreader is inserted, and the intrapericardial dissection of the aorta and right atrium is accomplished. Again, in most cases it is safest to find the correct dissection plane at the level of the diaphragm and then to continue around the right atrium to the aorta.
- The one situation in which this strategy may be dangerous is if an atherosclerotic vein graft to the right coronary artery lies over the right atrium. Manipulation of atherosclerotic vein grafts can cause embolization of atherosclerotic debris into coronary arteries, and it is best to employ a "no touch" technique with such grafts.
- If a vein graft to the right coronary artery lies in an awkward position over the right atrium, it is best to leave the right atrium alone and to use femoral vein and superior vena cava cannulation to establish venous drainage.
- Once cardiopulmonary bypass has been established, the aorta has been cross-clamped, and cardioplegia has been given, the atherosclerotic vein graft then can be disconnected.



- Manipulation of patent but atherosclerotic vein grafts should be avoided. If an atherosclerotic right coronary vein graft blocks access to the right atrium, femoral vein and direct superior vena cava cannulation are safer than mobilizing the vein graft in order to achieve right atrial cannulation.

- The goal of dissection of the ascending aorta is to obtain enough length for cannulation and cross-clamping and to avoid the most common error, aortic subadventitial dissection.
- The correct level of dissection on the aorta usually is found either by following the right atrium to the aorta in a caudal-to-cranial direction or by identifying the innominate vein and leaving all the tissue beneath the innominate vein on the aorta.
- At the level of the innominate vein, the pericardial reflection on each side of the aorta will be identifiable. Division of the pericardial reflection on the left side in a posterior direction will lead to the plane between the aorta and the pulmonary artery. Once the left side of the aorta is identified, the surgeon then may dissect posteriorly on the medial aspect of the left lung toward the hilum.
- The segment of tissue between these two dissection planes usually will include a patent left ITA graft, if present, and clamping that tissue will produce occlusion of the ITA graft.

- When the aorta has been dissected out, heparin is given, and cannulation is undertaken.
- Cannulation of an atherosclerotic ascending aorta may cause atherosclerotic embolization leading to stroke, myocardial infarction, or multiorgan failure, so the ascending aorta should be studied with palpation and echocardiography to detect atherosclerosis before cannulation.
- Although the most widely used alternative arterial cannulation site is the femoral artery, arteriopathic patients often have severe femoral artery atherosclerosis.
- The axillary artery is an alternative arterial cannulation site that is being used with increasing frequency because atherosclerotic disease is usually not present in that vessel, and its cannulation allows antegrade perfusion.



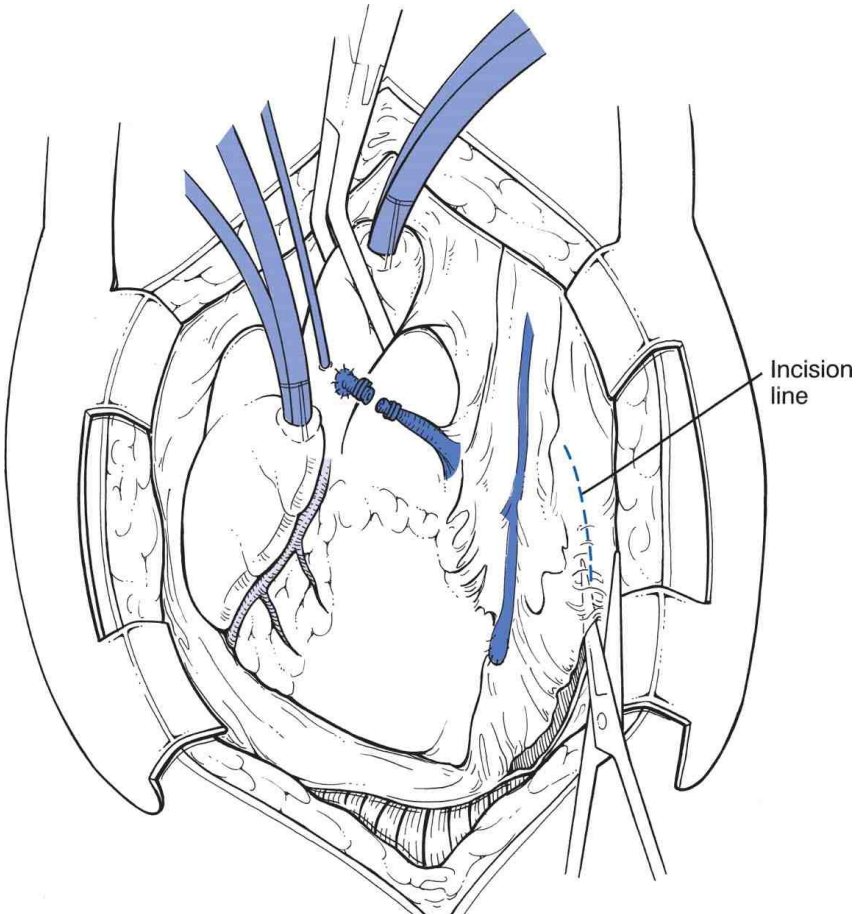
- Standard cannulation for coronary artery reoperation includes aortic arterial cannulation, an aortic needle for antegrade delivery of cardioplegia and aortic root venting, a single two-stage venous cannula, and a transatrial coronary sinus catheter with a self-inflating balloon for delivery of retrograde cardioplegia. Cannulation is accomplished prior to dissection of the left ventricle.

Myocardial Protection

- In most primary bypass operations, antegrade cardioplegia works well by itself. During reoperations, however, antegrade cardioplegia may not be effective for areas of myocardium that are supplied by patent in situ arterial grafts and may be dangerous because of the risk of embolization of atherosclerotic debris into the coronary arteries from old vein grafts.
- Retrograde cardioplegia delivery avoids atheroembolism from vein grafts, can be helpful in removing atherosclerotic debris and air from the coronary artery system, and can deliver cardioplegia to areas supplied by in situ arterial grafts.
- The biggest disadvantage of retrograde cardioplegia is that it is not always possible to place a catheter in the coronary sinuses that will deliver cardioplegia consistently.
- It is important to monitor the adequacy of cardioplegia delivery by measuring the pressure in the coronary sinus, noting the distention of cardiac veins with arterial blood, the cooling of the myocardium, and the return of desaturated blood from open coronary arteries.

- Cardiopulmonary bypass is begun, the perfusionist empties the heart and produces mild systemic hypothermia (34°C), and the aorta is cross-clamped. We usually initiate cardioplegia induction with aortic root cardioplegia.
- To induce and maintain cardioplegic protection, it is helpful to be able to occlude patent arterial grafts. If it has not yet been possible to dissect out a patent arterial graft so that it can be clamped, the systemic perfusion temperature is decreased to 25°C until control of the graft is achieved.
- After antegrade cardioplegia has been given for 2 to 3 minutes, we shift to retrograde induction for another 2 to 3 minutes. Giving any antegrade cardioplegia does risk embolization from atherosclerotic vein grafts, but if these grafts have not yet been manipulated, that danger is relatively small.
- Once the adequacy of retrograde cardioplegia delivery has been established, it is often possible to use that route predominantly for maintenance doses.

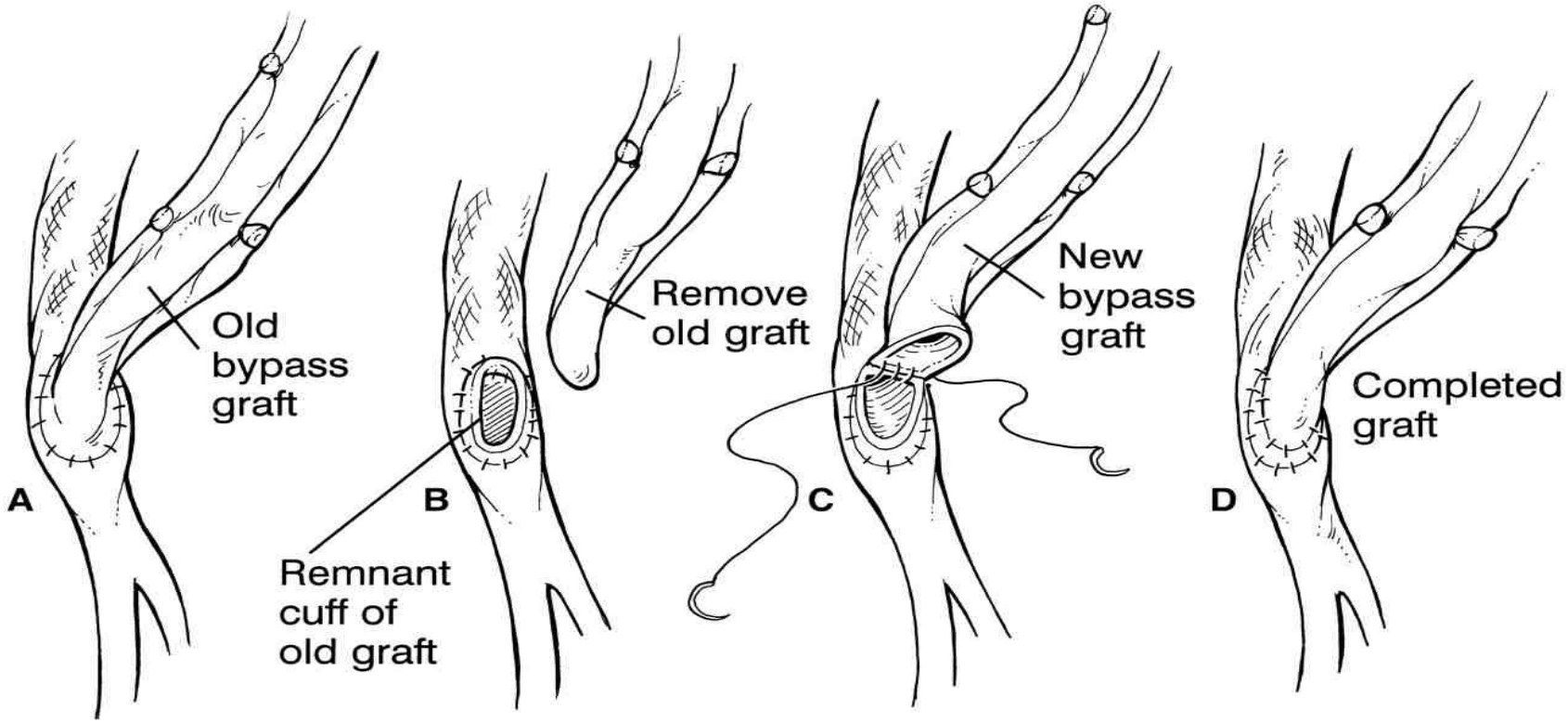
Intrapericardial Dissection



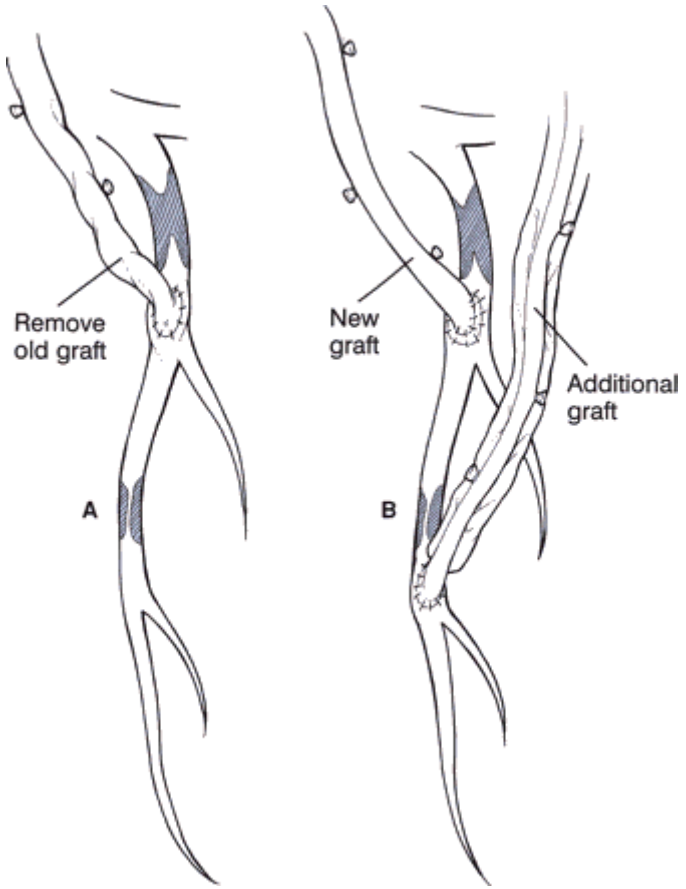
- Division of the pericardium along the diaphragm allows the surgeon to reach a point to the left of the cardiac apex. From that point, the pericardium can be divided in a cranial direction to the left of the LAD artery, leaving a patent ITA graft in the strip of tissue overlying the LAD artery. Atherosclerotic vein grafts that are going to be replaced may be divided once a dose of antegrade cardioplegia is given.

When the heart has been arrested completely, intrapericardial dissection of the left ventricle is undertaken, starting at the diaphragm and extending out to the left of the apex of the heart.

- After the heart is dissected out completely, the coronary arteries to be grafted can be identified, the lengths that bypass conduits need to reach those vessels may be assessed, and the final operative plan can be established.
- The old grafts and epicardial scarring that are present during reoperations make the preoperative prediction of the lengths of conduits needed for bypass grafts quite difficult, particularly the lengths of arterial grafts, and it is wise to have some flexibility in the operative plan.
- Prior to the construction of the anastomoses, those patent but atherosclerotic vein grafts that are going to be disconnected are identified and are disconnected with a scalpel.
- The order of anastomosis construction that is commonly used (1) distal vein graft anastomoses, (2) distal free arterial graft anastomoses, (3) distal in situ arterial graft anastomoses, and (4) proximal (aortic) anastomoses.

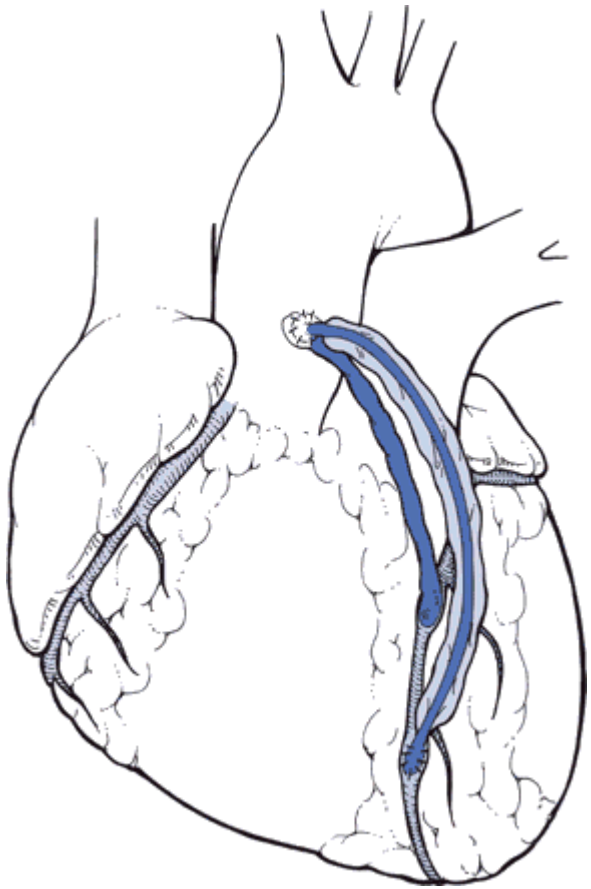


For patients with extensive native coronary atherosclerosis, the distal anastomotic site of an old vein graft is often the best spot for the distal anastomosis of a new graft. Only a small rim of the old graft should be left in place.

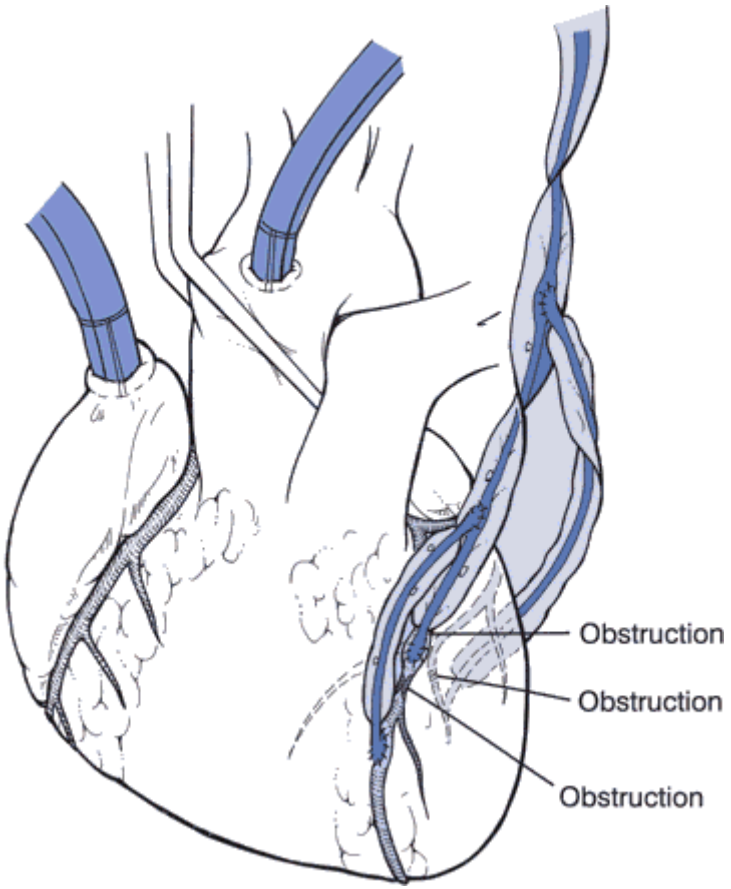


- Extension of native-vessel coronary artery disease may indicate the placement of new distal grafts as well as replacement of diseased vein grafts supplying proximal coronary artery segments.

- Artery-to-coronary-artery bypass grafts have many advantages during reoperations.
  - often available.
  - the tendency of arteries to remain patent even when used as grafts to diffusely diseased coronary arteries makes them particularly applicable to reoperative candidates.
  - in situ arterial grafts do not require a proximal anastomosis.
- If the left ITA has not been used as a graft at a previous operation, a strong attempt should be made to use it as an in situ graft to the LAD artery.
- During primary operations, the right ITA usually can be crossed over as an in situ graft to left-sided vessels, but such a plan is more difficult during repeat surgery, so the right ITA is often used as a free graft.
- Arterial graft proximal anastomoses are a problem at reoperation because the scarring and thickening of the reoperative aorta often make direct anastomoses of arterial grafts to the aorta unsatisfactory. However, when old vein grafts become occluded, there is usually a "bubble" of the hood of the old vein graft that is not atherosclerotic and that often is a good spot for construction of a free (aorta-to-coronary-artery) arterial graft anastomosis



- The hood of new or old vein grafts is often the best spot for the aortic anastomosis of free arterial grafts. Atherosclerosis rarely occurs in that "bubble" of vein.



- Composite arterial grafts can be constructed using a new or old left ITA graft as the inflow source. With its proximal anastomosis to the left ITA, a right ITA graft will easily reach the circumflex branches. Furthermore, a shorter segment of inferior epigastric artery or radial artery can be used to reach the distal LAD artery if intervening native LAD stenoses have limited the effectiveness of an old ITA graft.

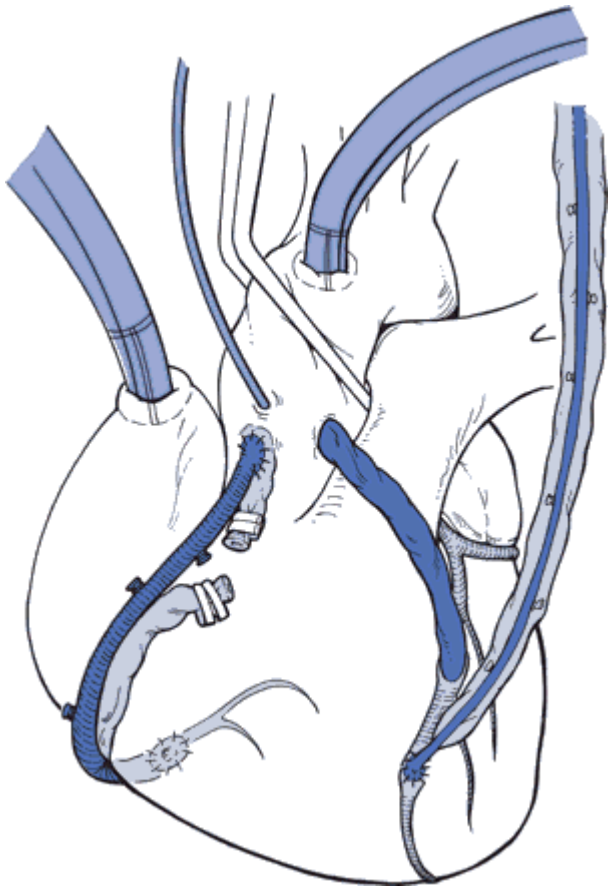
Can an ITA graft be used to replace a vein graft?

- The surgeon may leave the old vein graft in place and add an arterial graft to the same coronary vessel.
  - The dangers of this approach are that atherosclerotic embolization from the old vein may occur during the reoperation, and competitive flow between the vein graft and the arterial graft may jeopardize the ITA graft after reoperation.

- The surgeon may remove the old vein graft and replace it with an ITA graft.
  - This decreases the likelihood of atherosclerotic embolization and competitive flow but risks hypoperfusion during reoperation if the arterial graft cannot supply all the flow that had been generated previously by the vein graft.

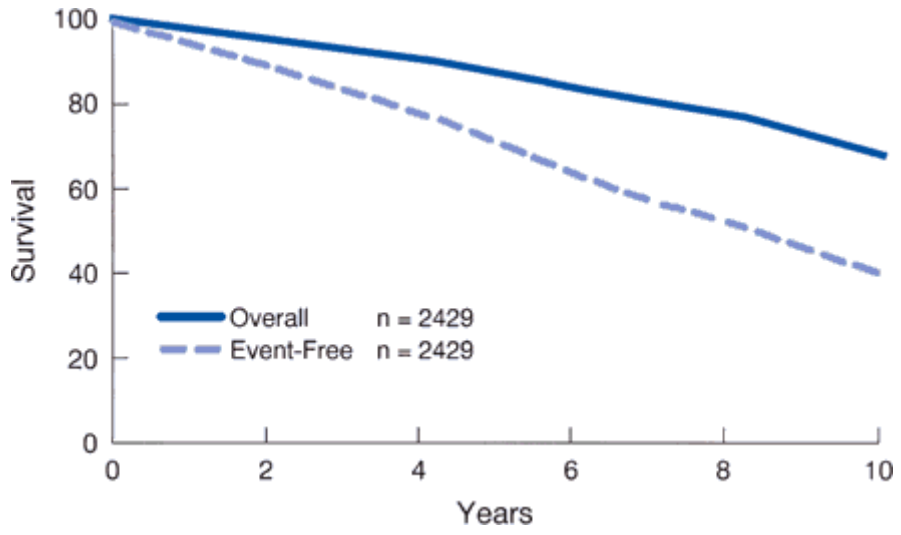
- The surgeon may replace the old vein graft with a new vein graft.
  - The disadvantage of this approach is a long-term one: The coronary vessel is left dependent on a vein graft.

- in a retrospective study of operations for patients with atherosclerotic vein grafts supplying the LAD artery, was found that the worst outcomes resulted from removing a patent (although stenotic) vein graft and replacing it with only an ITA graft. This strategy was associated with a significant incidence of hypoperfusion and severe hemodynamic difficulties during reoperation that were treated effectively only by adding a vein graft to the same coronary artery.
- The incidence of myocardial infarction associated with leaving a stenotic vein graft in place was low. Thus, atherosclerotic embolization from an atherosclerotic vein graft is a danger, but it appears that with the use of retrograde cardioplegia, it is not commonly a major catastrophe.
- Another potential disadvantage of the strategy of adding an ITA graft to a stenotic vein graft is that competition in flow from the stenotic vein graft may lead to failure of the new ITA graft. However, this is unlikely to occur as long as the stenosis in the SVG is severe.
- A common approach, therefore, is to remove atherosclerotic vein grafts when replacing them with a new vein graft but leave stenotic vein grafts in place when grafting the same vessel with an arterial graft.



- In this example, an atherosclerotic right coronary artery vein graft is disconnected and is replaced with a new vein graft. However, the stenotic vein graft to the LAD artery is left in place to avoid hypoperfusion, and a new ITA graft is added to the LAD artery.

Results



For 2429 hospital survivors who underwent reoperation between 1967 and 1987, the 10-year survival was 69%, and event-free survival was 41%. (*Loop FD, Lytle BW, Cosgrove DM, et al: Reoperation for coronary atherosclerosis: Changing practice in 2509 consecutive patients. Ann Surg 1990; 212:378.*)

- In a recent report by Sabik and colleagues, the hospital mortality rate for patients undergoing reoperative CABG was reduced to 2.5% in 2002, and risk adjustment identified the comorbidity burden carried by reoperative patients as a factor that increased risk, not reoperative status itself.14
- Recent mortality rates from other large series range from 4.2 to 11.4%, most being around 7%.4–9,52 All these figures are two to five times higher than the rates we would expect for the risk of primary CABG.
- Coronary artery reoperations have been associated with a higher in-hospital mortality mostly because of an increased risk of perioperative myocardial infarction. In the Cleveland Clinic Foundation series, the cause of perioperative death was cardiovascular in 85% of cases in the most recent cohort of patients undergoing reoperation, a figure that contrasts with recent studies of primary operations, in which noncardiac causes of death have been increasingly important.3,15 Furthermore, in the reoperative series, in-hospital mortality was associated with new perioperative myocardial infarction in 67% of cases.
- Multiple causes of myocardial infarction have been identified, including incomplete revascularization owing to distal CAD, vein graft thrombosis, ITA graft failure, atherosclerotic embolization from vein grafts, injury to bypass grafts, hypoperfusion from arterial grafts, preoperative myocardial infarction, and complications of PTCA.

Risk Factors for Reoperative Valve Surgery

- Advanced age
- Impaired ejection fraction (EF),
- congestive heart failure (CHF), or advanced preoperative functional class (NYHA)
- Urgency of operation or unstable status preoperatively
- Preoperative shock
- Concomitant coronary artery bypass graft (CABG) or the presence of previous bypass grafts
- Prosthetic valve endocarditis
- Surgery for perivalvular leaks, valve thrombosis, or prosthetic dysfunction
- Renal dysfunction
- Chronic abstructive pulmonary disease (COPD)

Approaches and Techniques

- Prior to proceeding with a resternotomy, the relationship between certain anterior mediastinal structures (e.g., the right ventricle and the aorta) and the posterior aspect of the sternum must be assessed carefully.47
- This generally can be visualized on chest radiograph or more accurately with a computed tomographic (CT) scan.
- Recently, it has been shown that multidetector computed tomographic (MDCT) scanning, in combination with retrospective electrocardiographic gating, can be used as a noninvasive way to assess not only the heart's location in relation to the sternum but also graft location and patency.