Coronary Artery Reoperations

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Introduction

Coronary artery reoperations are more complicated than primary operations.

Vein graft atherosclerosis, present in most reoperative candidates, is a unique and dangerous lesion.

Aortic atherosclerosis are also often far advanced in many reoperative candidates.

Some technical hazards, including the presence of patent arterial grafts and sternal reentry, are unique to reoperations, and others, such as lack of bypass conduits and difficult coronary artery exposure, are common.

INCIDENCE OF REOPERATION

After a primary bypass operation, the likelihood of a patient undergoing a reoperation depends on patient-related variables, primary operation-related variables, adherence to strict medical control of risk factors for disease progression after bypass surgery.

Studies from our institution noted a cumulative incidence of reoperation of 3% by 5 years, 10% by 10 years, and 25% by 20 postoperative years .

Factors associated statistically with an increased likelihood of reoperation have been variables predicting a favorable long-term survival (*eg, young age,, and single- or double-vessel disease*), **variables designating an imperfect primary operation** (eg, no internal thoracic artery [ITA] graft and incomplete revascularization).

Young age at primary operation and incomplete revascularization are also markers of a severe atherogenic diathesis.

INCIDENCE OF REOPERATION

Reoperations has decreased.

This decrease is related in part to the more aggressive use of coronary artery interventions **PCI** for patients with previous bypass surgery and probably to more effective risk factor control.

Use of the left internal thoracic artery (LITA) to graft the left anterior descending (LAD) coronary artery decreases the risk of reoperation compared with the strategy of using only vein grafts, and the LITA-LAD graft has become a standard part of operations for coronary artery revascularization.

Furthermore, it now appears that use of **bilateral ITA grafts** decreases the likelihood of death and reoperation when compared with the single LITA-LAD strategy .

INCIDENCE OF REOPERATION

Cleveland Clinic Foundation studies have shown that in the early years of bypass surgery only **28%** of patients underwent reoperation solely because of **graft failure**, and that graft failure often occurred **early after the primary operation** (mean postoperative interval of 28 months after primary operation).

Reoperation because of the progression of **atherosclerosis in nongrafted coronary arteries** was common in **55% of patients**, almost all patients had graft failure as at least part of the indication for reoperation (92%).

Today, patients undergoing reoperation usually had a successful primary operation at least 10 years previously for the treatment of multivessel CAD, and the angiographic indications for reoperation are ***progression of native-vessel distal CAD in combination with late graft failure caused by vein graft atherosclerosis***.

GRAFT FAILURE

Saphenous vein to coronary artery grafts exhibit different pathologies at different intervals after operation.

Within a **few months**, they often have diffuse endothelial disruptions with associated mural thrombus.

The mural thrombus usually is **not obstructing**.

Most saphenous vein grafts examined more than 2 to 3 months after operation have developed a **proliferative intimal fibroplasia.**

This is a concentric cellular process, and it is diffuse, extending the entire length of the graft , although intimal fibroplasia involves most vein grafts, ***it causes stenoses or occlusions of only a few.***

Vein graft atherosclerosis is a distinct pathologic process that often is recognized as early as **3 to 4 years** after operation and is characterized by lipid infiltration of areas of intimal fibroplasia.

Vein graft atherosclerosis is seen in a majority of grafts explanted more than 10 years after surgery whether or not those grafts are stenotic.

GRAFT FAILURE

Atherosclerotic lesions appear to account for almost *all late saphenous vein graft (SVG) stenosis* whether or not those grafts are stenotic.

The extreme friability of vein graft atherosclerosis creates a substantial risk of distal coronary artery embolization during percutaneous interventions to treat stenotic lesions and during reoperations for patients with atherosclerotic vein grafts.

It is also probable that spontaneous coronary artery embolization may occur from atherosclerotic grafts.

However, it appears that by 10 years after operation, approximately 30% of vein grafts are totally occluded, and 30% of patent grafts exhibit some degree of stenosis or intimal irregularities characteristic of vein graft atherosclerosis.

Native-vessel stenosis distal to the insertion site of vein grafts may decrease SVG graft outflow and contribute to graft failure.

Progress has been made toward decreasing the rate of vein graft failure:

The early patency rates of SVGs have been improved by the use of perioperative and long-term platelet inhibitors.

Some studies now indicate that lipid-lowering regimens decrease late vein graft disease and the risk of late cardiac events.

The only way known to avoid vein graft atherosclerosis is to avoid using vein grafts.

ITA grafts rarely develop late atherosclerosis, and the late attrition rate of patent ITA grafts is extremely low.

Left ITA to LAD grafts have a very high late (20 years) patency rate.

INDICATIONS FOR REOPERATION

Anatomical indications for reoperation to improve survival prognosis include:

(1) atherosclerotic (**late**) stenoses in vein grafts that supply the LAD artery.

(2) multiple stenotic vein grafts that supply large areas of myocardium.

(3) 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.

Reoperation is also effective in other anatomical situations in which severe symptoms are the indication for invasive treatment, **including patients with a patent ITA to LAD graft combined with other ischemia-producing pathology and multiple early vein graft stenosis**.

PERCUTANEOUS TREATMENT OF POSTOPERATIVE PATIENTS

Realistically, the ideal uses of PCTs are in situations in which failure of the anatomical treatment is not likely to be catastrophic as the impact of stenting on survival is unclear

These situations include ***symptomatic patients with***:

(1) Early vein graft stenosis.

(2) Native coronary stenosis.

(3) Focal late SVG stenoses in vein grafts not supplying the LAD artery.

TABLE 26-2 Reoperation versus PTCA for Patients with Stenotic Vein Grafts

Factors Favoring Reoperation	Factors Favoring PTCA
Late (≥5 years) stenoses	Early (<5 years) stenoses
Multiple stenotic vein grafts	Single stenotic vein graft
Diffusely atherosclerotic vein grafts	Other patent vein grafts
Stenotic LAD vein graft	Focal graft lesions
No patent ITA graft	Patent ITA-LAD graft
Abnormal left ventricular function	Normal left ventricular function

TECHNICAL ASPECTS OF CORONARY REOPERATIONS

Reoperations are more complicated than primary operations.

The specific technical challenges that surgeons must recognize and solve that are unique to or more common during coronary reoperation are:

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

The overall problem of **myocardial protection** is more difficult during reoperations, with perioperative myocardial infarction still being the most common cause of in-hospital death.

These anatomical 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.

failure to deliver cardioplegic solution.

incomplete revascularization.

and technical error.

Preoperative Assessment

A complete understanding of the patient's native coronary and bypass graft anatomy is essential.

If bypass grafts, venous or arterial, are not demonstrated by a preoperative coronary angiogram, it usually means that they are occluded, but it is also possible that the angiogram simply has failed to demonstrate their location.

It is also important to know that graftable stenotic coronary arteries supply viable myocardium.

Myocardial scar and viability can be differentiated by thallium scanning, positron-emission tomography, and stress (exercise or dobutamine) echocardiography.

Before embarking on a reoperation, it makes sense to be reasonably sure that there is a matchup between the patient's graftable arteries and some viable myocardium such that grafting those arteries will provide some long-term benefits.

It is also wise to have a preoperative **plan for bypass conduit selection** and to document that potential bypass conduits are available.

ITA angiography often is helpful.

Venous Doppler studies can be used to assess the presence of greater and lesser saphenous vein segments.

Median Sternotomy Incision, Conduit Preparation, and Cannulation

Most coronary reoperations are performed through a median sternotomy.

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.

Difficulty reopening the sternum during a previous reoperation.

Median Sternotomy Incision, Conduit Preparation, and Cannulation

In such situations, vessels for arterial via the (femoral or axillary artery) and *venous access for cardiopulmonary bypass are dissected out before sternal reentry.*

Bypass grafts except for the internal thoracic arteries may be prepared before sternal reentry.

The most common structure injured during reentry is a bypass graft.

When reopening a median sternotomy, the incision is made to the level of the sternal wires; the *wires are cut anteriorly and bent back but are not removed.*

An oscillating saw is used to divide the anterior table of the sternum.

When the anterior table has been divided, ventilation is stopped, and the assistants elevate each side of the sternum with rake retractors while the posterior table of the sternum is divided in a caudalcranial direction.

Median Sternotomy Incision, Conduit Preparation, and Cannulation

The sternal wires that have been left in place posterior to the sternum **help to protect underlying structures.**

Once the posterior table of the sternum has been divided with the saw, the wires are removed, and sharp dissection with scissors is used to separate each side of the sternum from underlying structures.

Once the sternum has been divided, it is important that the assistants retract in an upward direction, **not** laterally.

The **right ventricle** is injured more often **by lateral retraction** while it is still adherent to the underside of the sternum than it is by a direct saw injury.

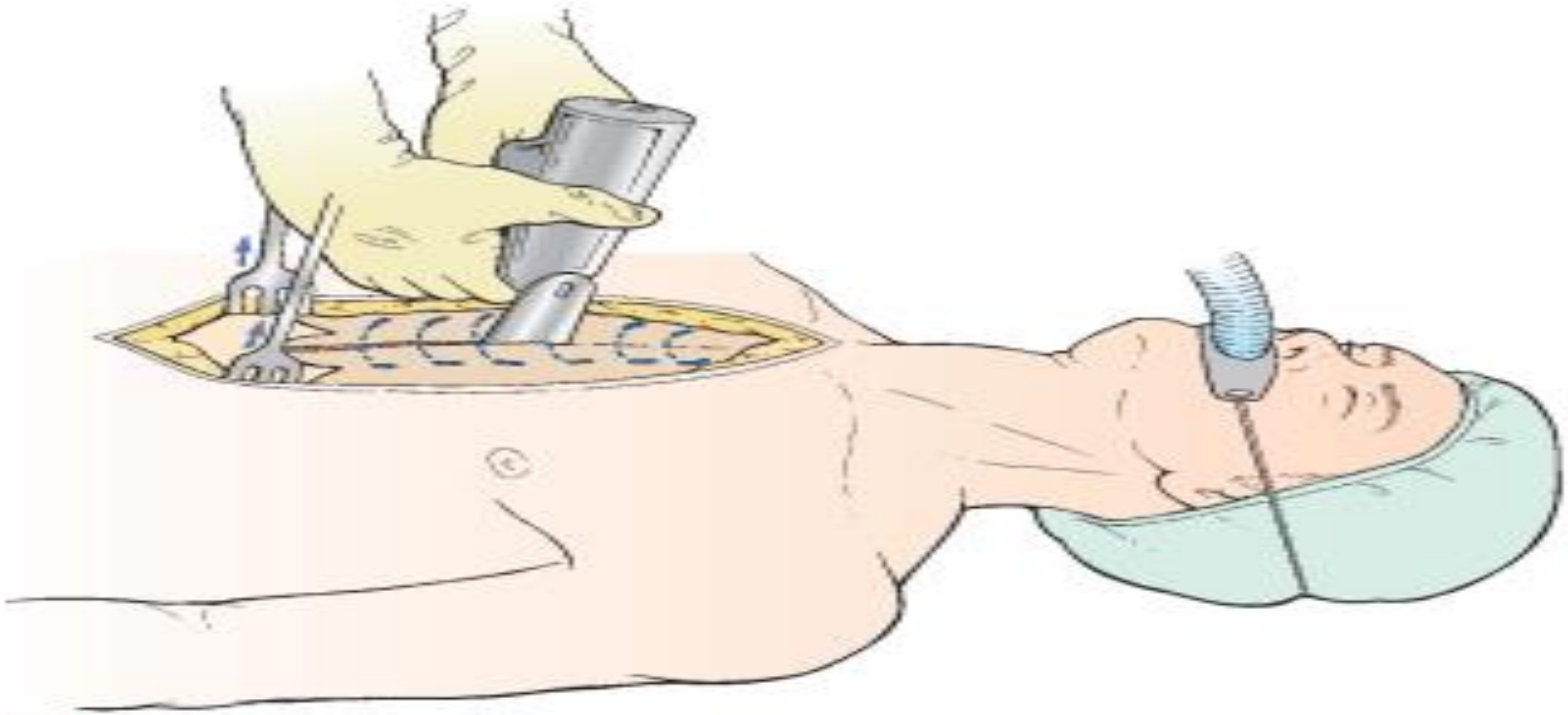


FIGURE 26-9 Leaving the sternal wires in place posteriorly helps to protect underlying structures while the posterior table of the sternum is divided with an oscillating saw. The direction of retraction with rake retractors should be anterior, not lateral.

Median Sternotomy Incision, Conduit Preparation, and Cannulation

In high-risk situations, it can be helpful to perform a small anterolateral right thoracotomy before the repeat median sternotomy.

Underlying structures, such as the aorta, patent bypass grafts, and the right atrium and ventricle, can be dissected away from the sternum via this approach, and thus, with the surgeon's hand placed behind the sternum, reentry is safe.

This small additional incision contributes little morbidity.

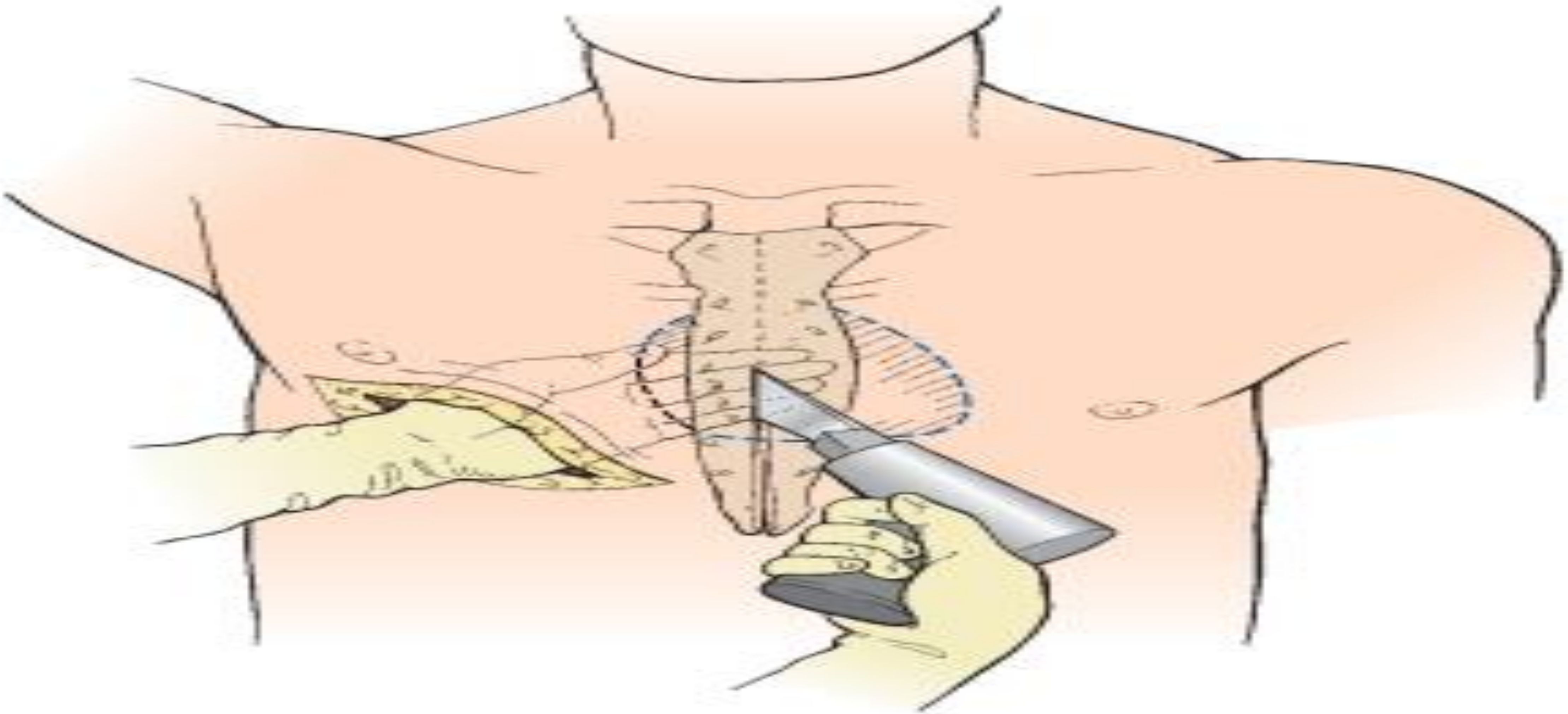


FIGURE 26-10 A small anterolateral right thoracotomy allows dissection of substernal structures such as patent grafts and the right ventricle or aorta away from the sternum under direct vision. While the sternum is being divided, the surgeon may place a hand behind the sternum for further safety.

Median Sternotomy Incision, Conduit Preparation, and Cannulation

Another technique for sternal reentry in **high-risk patients** is to heparinize, *cannulate, and initiate cardiopulmonary bypass before median sternotomy.*

The **advantages** of this strategy are that 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.

The **disadvantages** of this approach are that 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.

Median Sternotomy Incision, Conduit Preparation, and Cannulation

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**.

Therefore, at this point in the operation we usually dissect along the level of the diaphragm to the patient's right side until we enter the pleural cavity and then detach the pleural reflection from the chest wall in a cranial direction to the level of the innominate vein.

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**.

Median Sternotomy Incision, Conduit Preparation, and Cannulation

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.

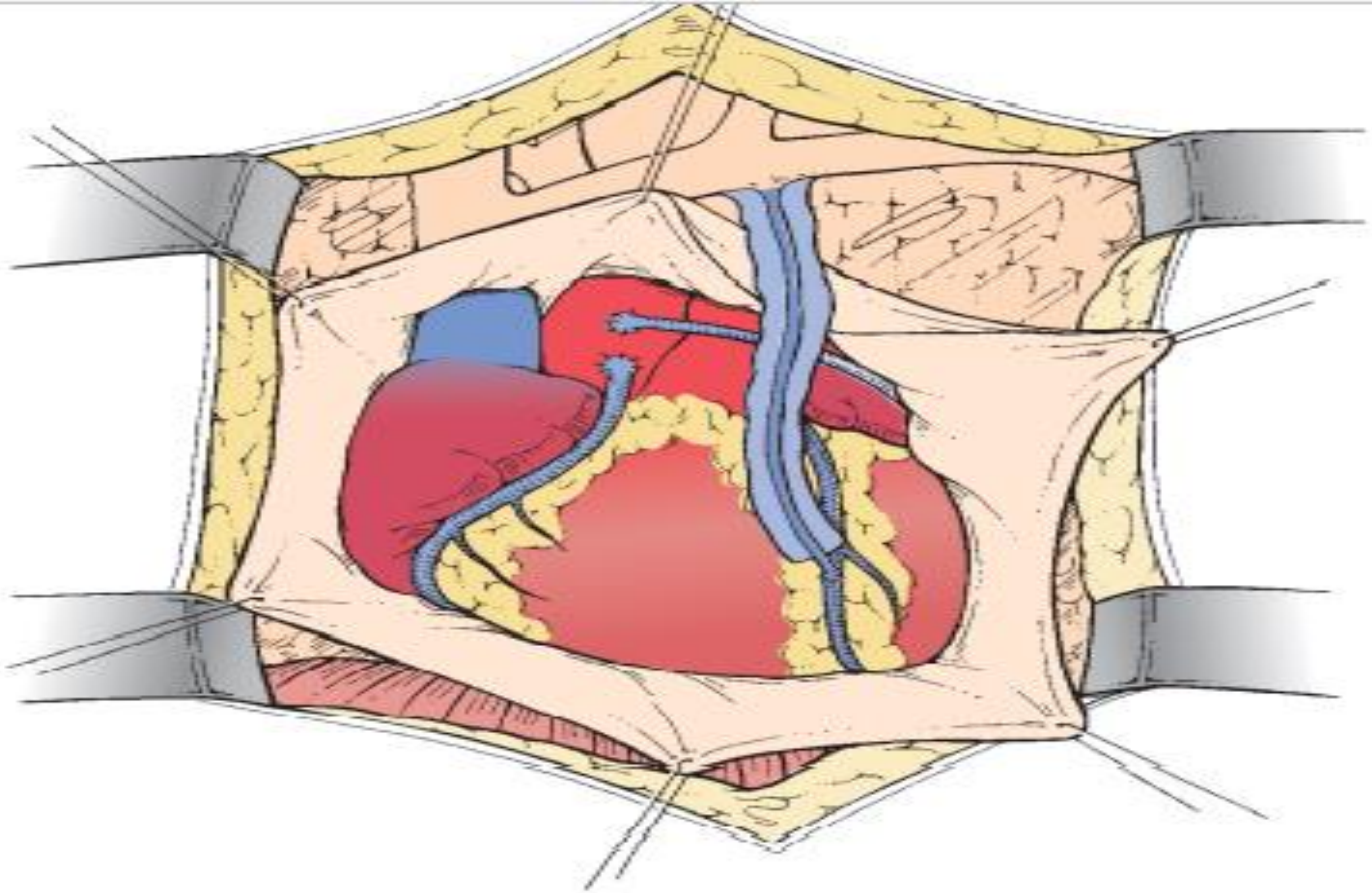
This is ***difficult only if there is a patent ITA graft that is densely adherent to the chest wall.***

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 .

Ideally, the *pericardium should be divided at a primary operation*, and the left *ITA graft should be allowed to run posterior to the lung through the incision* in the pericardium and to the LAD or circumflex artery.

When this is done, the lung will lay anterior to the left ITA, and that graft will not become adherent to the aorta or to the chest wall.



Median Sternotomy Incision, Conduit Preparation, and Cannulation

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 use the 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.***

Myocardial Protection

The myocardial protection strategy used by us during most coronary artery reoperations is a ***combination of antegrade and retrograde delivery of intermittent cold blood cardioplegia combined with a dose of warm reperfusion cardioplegia ("hot shot")*** given before aortic unclamping.

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 .

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.

Myocardial Protection

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***.

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.

Intrapericardial Dissection

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.

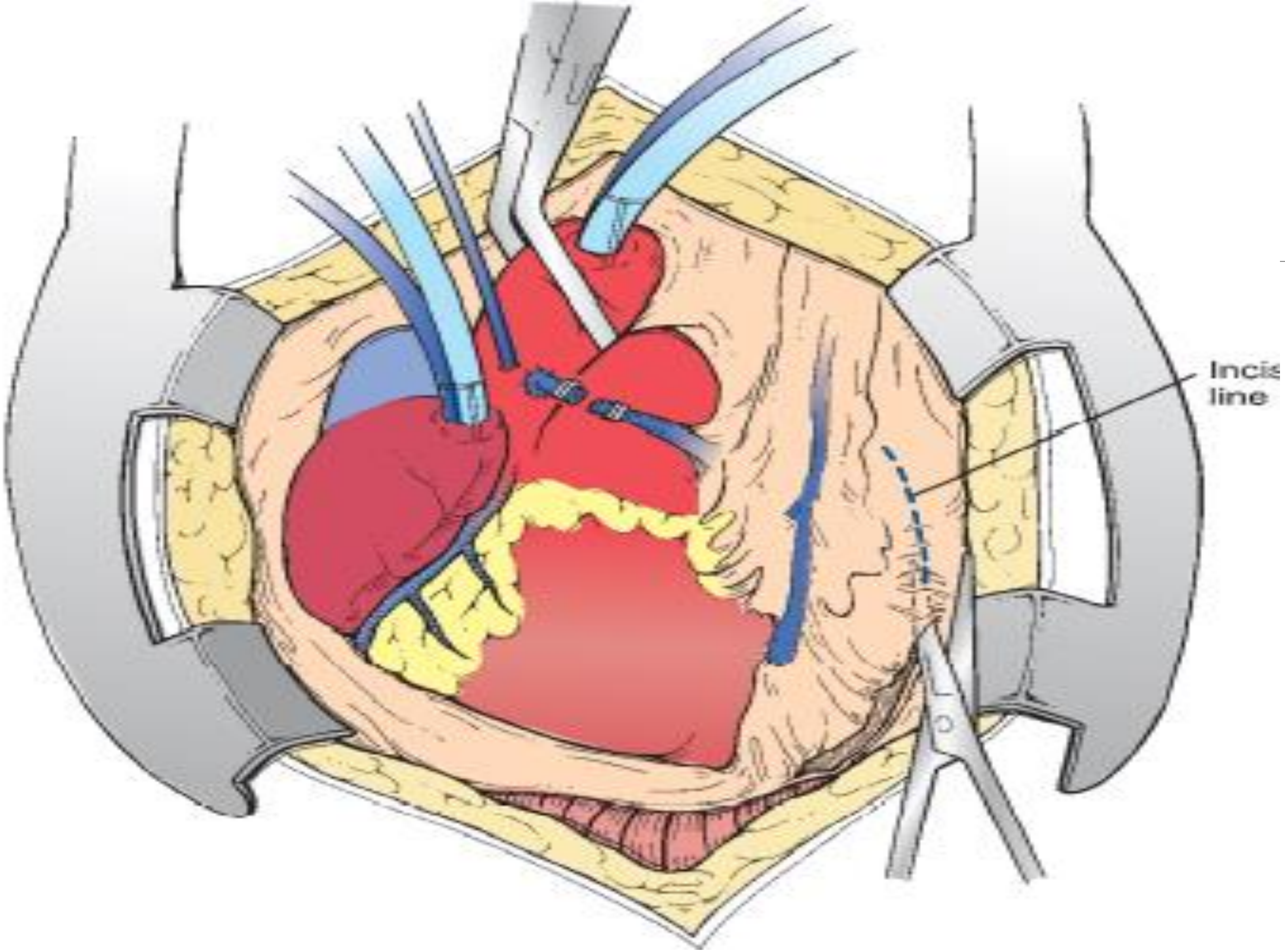
After the apex is identified, the surgeon divides the pericardium in a cranial direction on the left side of the LAD artery .

A patent LITA-to-LAD graft will be contained within the strip of pericardium that lies over the LAD artery.

Dissection of this pedicle from the anterior aspect of the pulmonary artery will ***allow an atraumatic clamp to be placed across the patent ITA graft*** and also will ***allow the passage of new bypass grafts from the aorta underneath the patent ITA graft to left-sided coronary arteries.***

The advantages of waiting until after aortic clamping and arrest to:

dissect out the left ventricle are that dissection is more accurate, there is less damage to the epicardium and less bleeding, manipulation of atherosclerotic vein grafts is less likely to cause coronary embolization, and the dissection of patent ITA grafts is safer.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line

Intrapericardial Dissection

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.

Before 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 used by the authors is: (1) distal vein graft anastomoses; (2) distal free arterial graft anastomoses; (3) distal in situ arterial graft anastomoses; and (4) proximal (aortic) anastomoses.

Stenotic Vein Grafts

Atherosclerosis in vein grafts is common if those grafts are ***more than 5 years old***, and leaving them in place risks embolization of atherosclerotic debris at the time of reoperation and subsequent development of premature graft stenoses or occlusions after reoperation.

In the past, our general rule has been to ***replace all vein grafts that are more than 5 years*** old at the time of reoperation, even if those grafts are not diseased angiographically.

Today, many patients have very *limited conduits* at reoperation because of the large numbers of vein grafts used at primary surgery or because of multiple previous operations.

Thus, graft replacement must be individualized.

Stenotic Vein Grafts

Inspection of vein grafts at reoperation occasionally will identify a graft that looks normal angiographically and does not appear to have any thickening or atherosclerosis on visual inspection.

Often such vein grafts will be **left alone**.

Replacing old vein grafts with new vein grafts may often be accomplished by creating the new vein-to-coronary-artery anastomosis at the site of the previous distal anastomosis, leaving only 1 mm or so of the old vein in place

Stenotic Vein Grafts

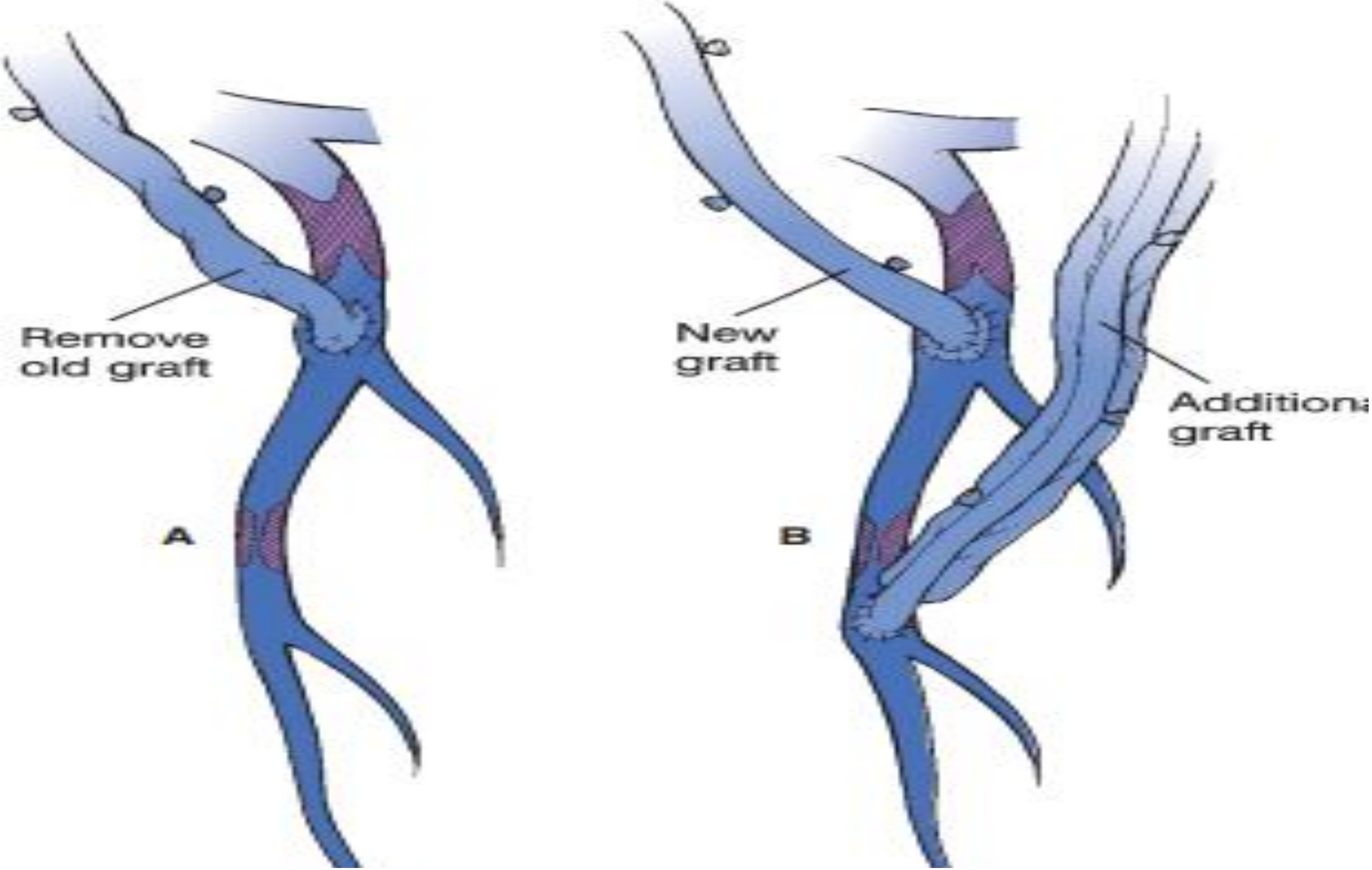
FIGURE 26-16 For patients with extensive native coronary atherosclerosis, the distal anastomotic site of an old vein graft is often the best spot for the distal anastomosis of a new graft. Only a small rim of the old graft should be left in place.

Stenotic Vein Grafts

If significant native-vessel stenoses have developed **distal to the old vein graft**, it is often *best to place a new graft to the distal vessel in addition to replacing the vein graft*.

Many reoperative candidates have proximal occlusions of the native coronary artery system and multiple stenoses throughout the vessel, and if only new distal grafts are constructed, the proximal segments of coronary arteries and their branches that are supplied by atherosclerotic vein grafts may be jeopardized.

More than one graft to a major coronary artery may be desirable during reoperation .


Remove
old graft
A
New
graft
B
Additiona
graft

Stenotic Vein Grafts

Sequential vein grafts often are very helpful during reoperation because they allow more distal anastomoses and fewer proximal anastomoses.

Sites for proximal anastomoses are often at a premium in the ***scarred reoperative aorta.***

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***.

proximal anastomoses

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 .

In addition, if **new vein grafts are performed**, the hood of that new vein graft represents a favorable location for an arterial graft anastomosis.

Composite arterial grafts, usually using a new in situ left ITA graft at the proximal anastomotic site for a free right ITA graft, have been employed with increasing frequency, and early outcomes have been favorable.

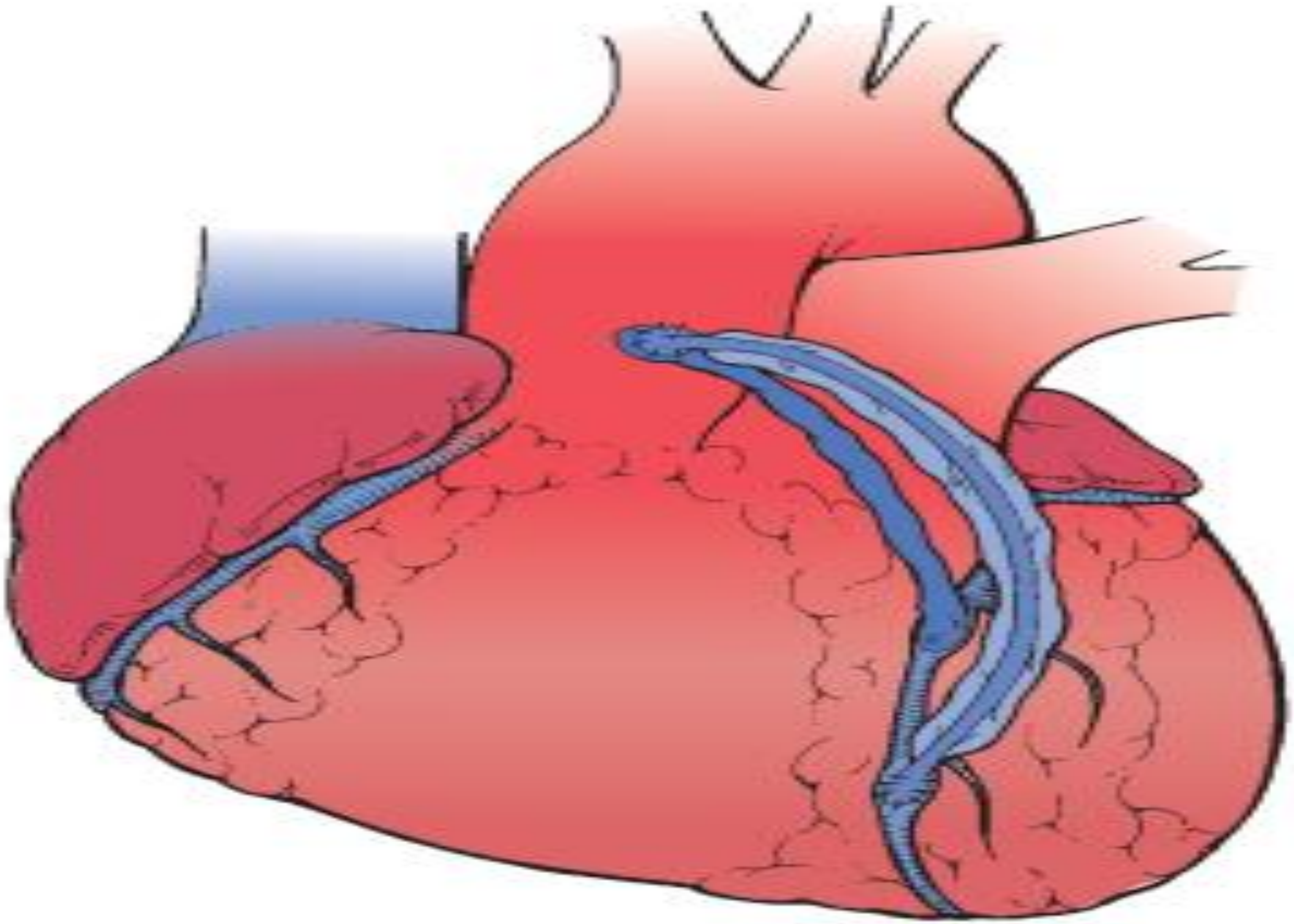


FIGURE 26-18 The hood of new or old vein grafts is often the best spot for the aortic anastomosis of free arterial grafts.

Can an ITA graft be used to replace a vein graft during reoperation? When faced with replacing a stenotic or patent vein graft during reoperation, the surgeon has a number of options, all of which have some potential disadvantages:

1. 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.

2. 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.

3. The surgeon may replace the old vein graft with a new vein graft.

The **disadvantage** of this approach is a long-term.

When we examined these choices in a retrospective study of operations for patients with atherosclerotic vein grafts supplying the LAD artery, we found that ***the worst outcomes resulted from removing a patent (although stenotic) vein graft and replacing it with only an ITA graft.***

Our usual 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.

The aortic anastomoses of the vein and arterial grafts are performed last during the ***single period of aortic cross-clamping.***

Often the locations of the previous vein graft proximal anastomoses are the best locations for the new ones.

The **advantages** of constructing aortic anastomoses during a single period of aortic cross-clamping are that it ***minimizes aortic trauma*** and allows ***excellent visualization of the proximal anastomoses***.

The disadvantage of this approach is that it prolongs the period of aortic cross-clamping.

RESULTS OF CORONARY ARTERY REOPERATIONS

A study from the Society of Thoracic Surgeons (STS) database reported an in-hospital mortality rate of **6.95**% associated with reoperations .

Recent mortality rates from other large series range from 4.2 to 11.4%, most being around 7%.

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.

Multiple causes of myocardial infarction have been identified, including

Incomplete revascularization.

ITA graft failure.

Atherosclerotic embolization from vein grafts.

Injury to bypass grafts.

Data from the STS for the year 1997 documented a ***risk of***

5.2% for elective reoperations.

7.4% for urgent reoperations.

13.5% for emergency reoperations.

40.7% for “salvage” reoperations.

THE END