Basic Vascular Skills Open Surgical techniques

By
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- Despite advances in endovascular technology and the increase in the number of endovascular interventions, open vascular reconstructions will continue to play a significant role in the management of patients with vascular disease for the foreseeable future.

Basic Principles

The key elements of a successful open vascular reconstructionare choosing the right procedure and vascular exposure and then executing the selected procedure correctly.

Appropriate choices for the source of inflow, the target for outflow, and the proper conduit, if needed, are critical for success of any revascularization.

This success also requires the appropriate instruments, graft, and suture materials. In addition, open vascular procedures should be performed under excellent lighting aided by magnifying loupes in select cases.

Vascular Instruments and Retractors

- A vascular instrument tray typically includes vascular clamps,needle holders, forceps, scissors, and various retractors.
- Depending on the size of the vessel and the location of the surgical reconstruction, the instruments used will vary.

Clamps

Clamps

Vascular clamps typically have jaws with rows of fine interdigitating serrations that allow clamping of the vessel without slippage or significant crush injury.

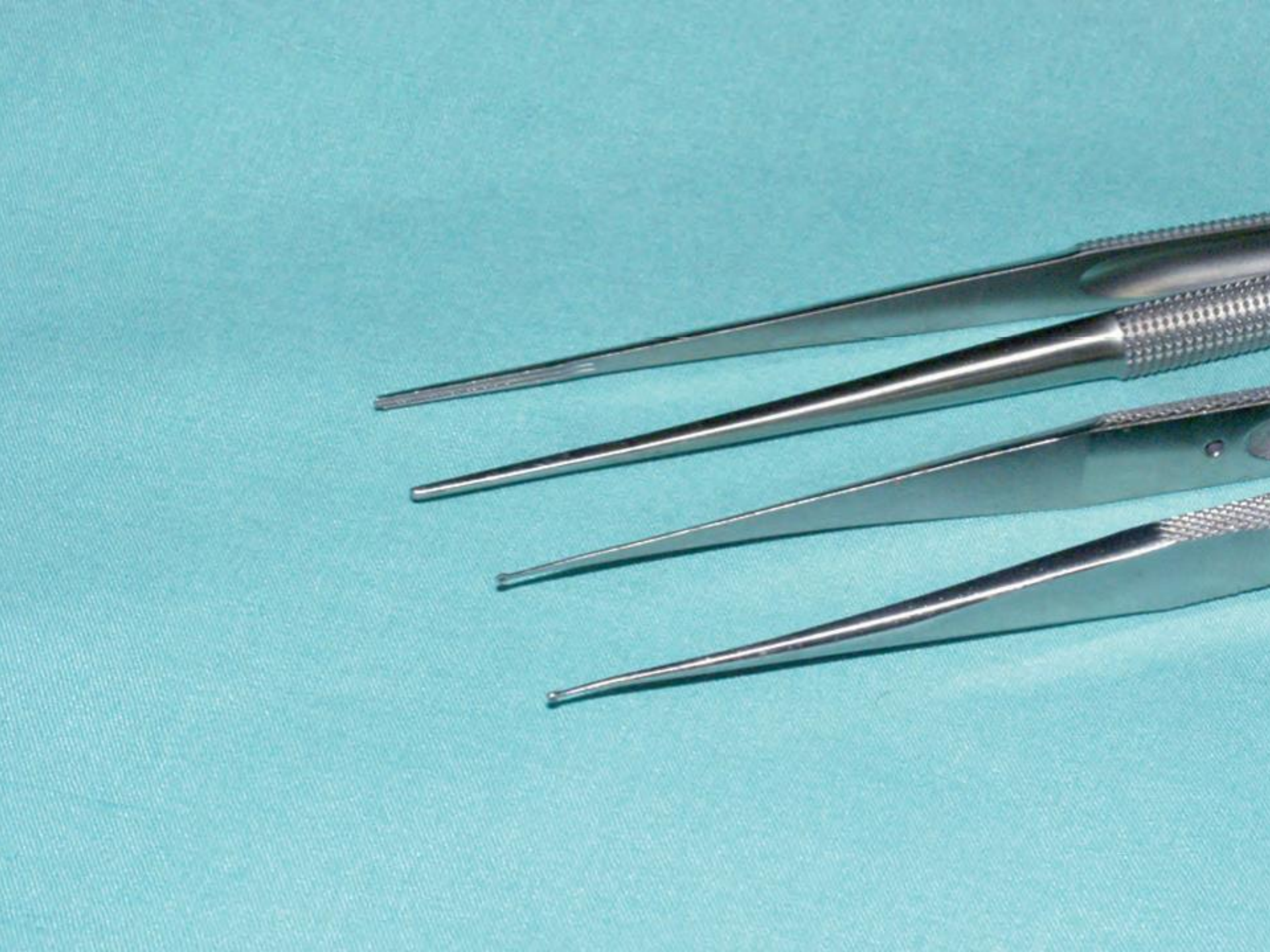
Although vascular clamps are considered atraumatic, a vascular clamp applied inappropriately can cause significant intimal damage or may tear the artery if placed over a plaque in an inappropriate manner.

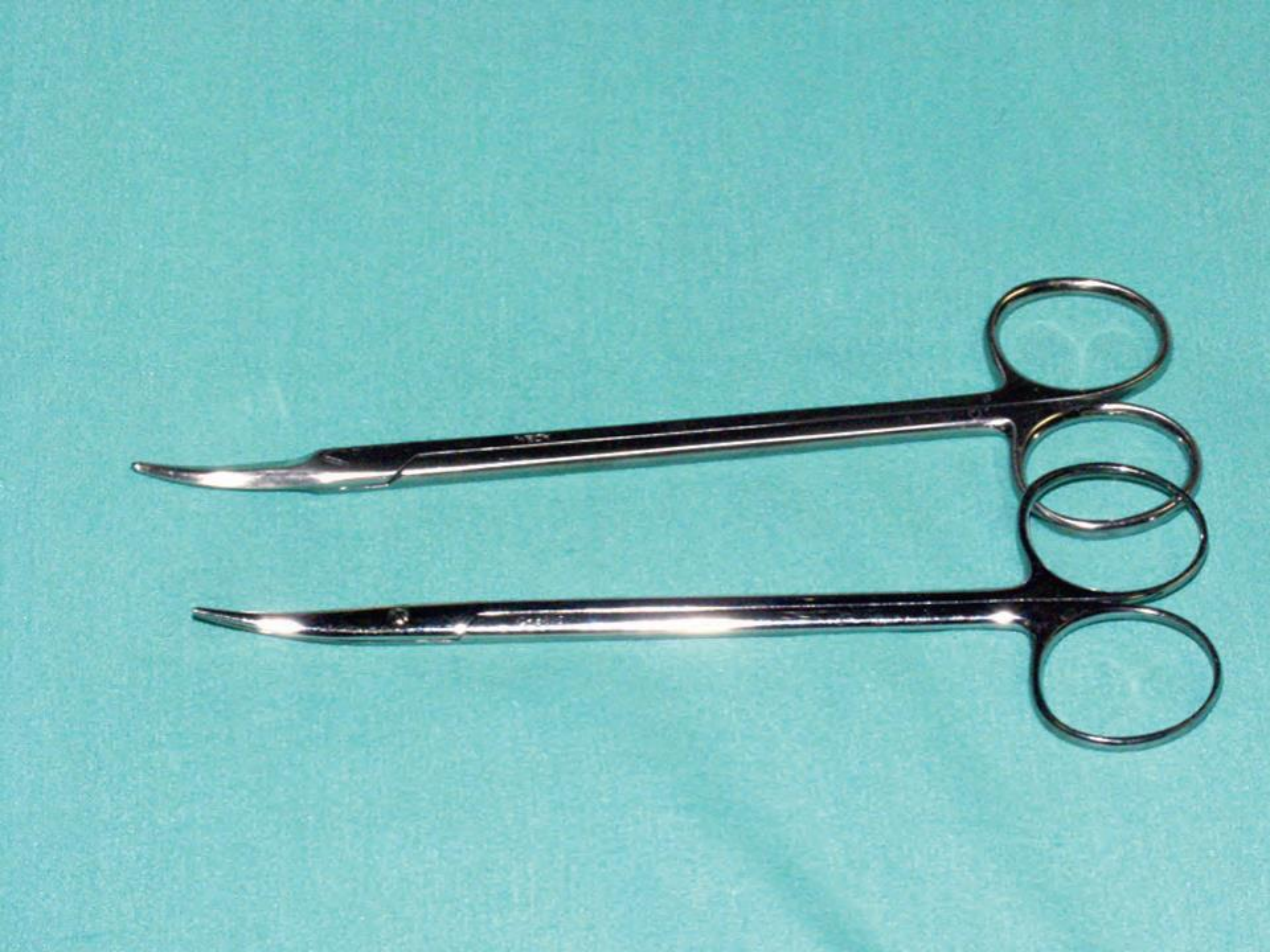
Even in a soft, minimally diseased artery, a clamp applied with excessive force can damage the arterial wall and intima.

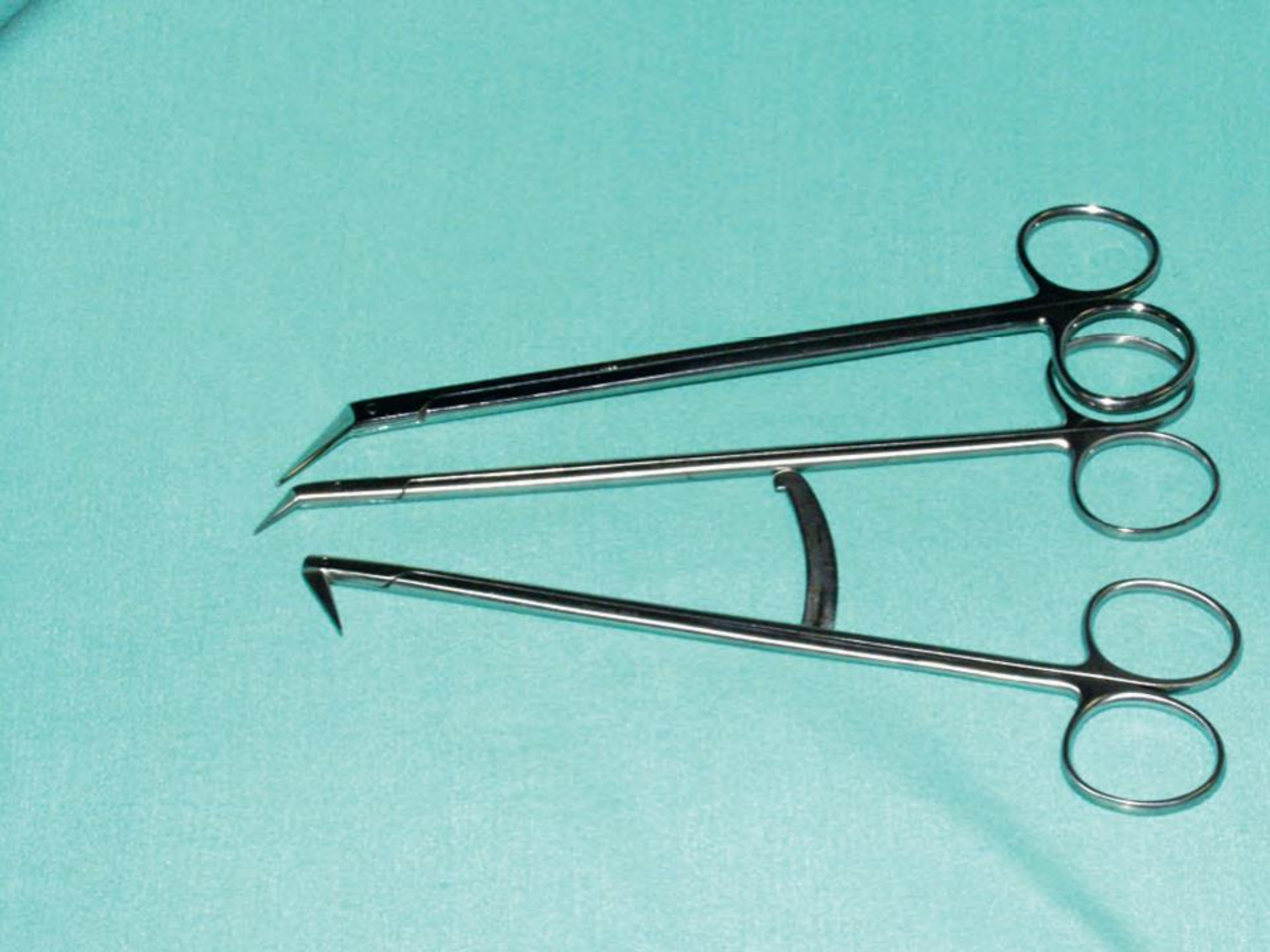
Table 87-1	Vascular Clamps and Target Vessels
Clamp Type	**Vessel**
TOTALLY OCCLUDING	
DeBakey aortic aneurysm clamp (side-to-side apposition of aortic wall)	Supraceliac, infrarenal aorta
DeBakey-Bahnson aortic aneurysm clamp	Infrarenal aorta
Howard-DeBakey aortic aneurysm clamp with reverse curve shafts (side-to-side apposition of aortic wall)	Infrarenal aorta
Fogarty aortic clamp (side-to-side apposition of aortic wall)	Infrarenal aorta; aortic grafts, calcified aorta
DeBakey aortic aneurysm clamp (apposition of anterior and posterior walls together)	Infrarenal aorta
Lambert-Kay aortic clamp (apposition of anterior and posterior walls together)	Infrarenal aorta
Wylie hypogastric clamp	Iliac arteries, especially hypogastric arteries

DeBakey peripheral vascular clamp (angled handle)	Iliac arteries
DeBakey peripheral vascular clamp (angled jaw, 45 degrees)	Iliac and common carotid arteries
Henly subclavian clamp	Subclavian and common femoral arteries
PARTIALLY OCCLUDING (SIDE-BITING)	
Lemole-Strong aortic clamp	Aorta; aortic grafts
Satinsky clamp	Aorta, vena cava
Cooley anastomosis clamp	Aorta; aortic grafts
Cooley-Derra clamp	Graft limbs
Cooley pediatric clamp	Common femoral artery, saphenofemoral junction
SELF-COMPRESSING (NO APPLICATOR REQUIRED)	
Gregory carotid "soft" bulldog	Small vessels
Potts bulldog—straight and angled jaw	Small vessels
DeBakey bulldog	Small vessels
Dietrich bulldog	Small vessels

SELF-COMPRESSING (NO APPLICATOR REQUIRED)	
Gregory carotid "soft" bulldog	Small vessels
Potts bulldog—straight and angled jaw	Small vessels
DeBakey bulldog	Small vessels
Dietrich bulldog	Small vessels
SELF-COMPRESSING (APPLICATOR REQUIRED)	
Yasargil aneurysm clip	Small vessels and branches
Heifitz clip	Small vessels and branches
Kleinert-Kutz clip—straight, angled, curved	Microvascular anastomoses
Louisville microvessel approximator	Microvascular anastomoses



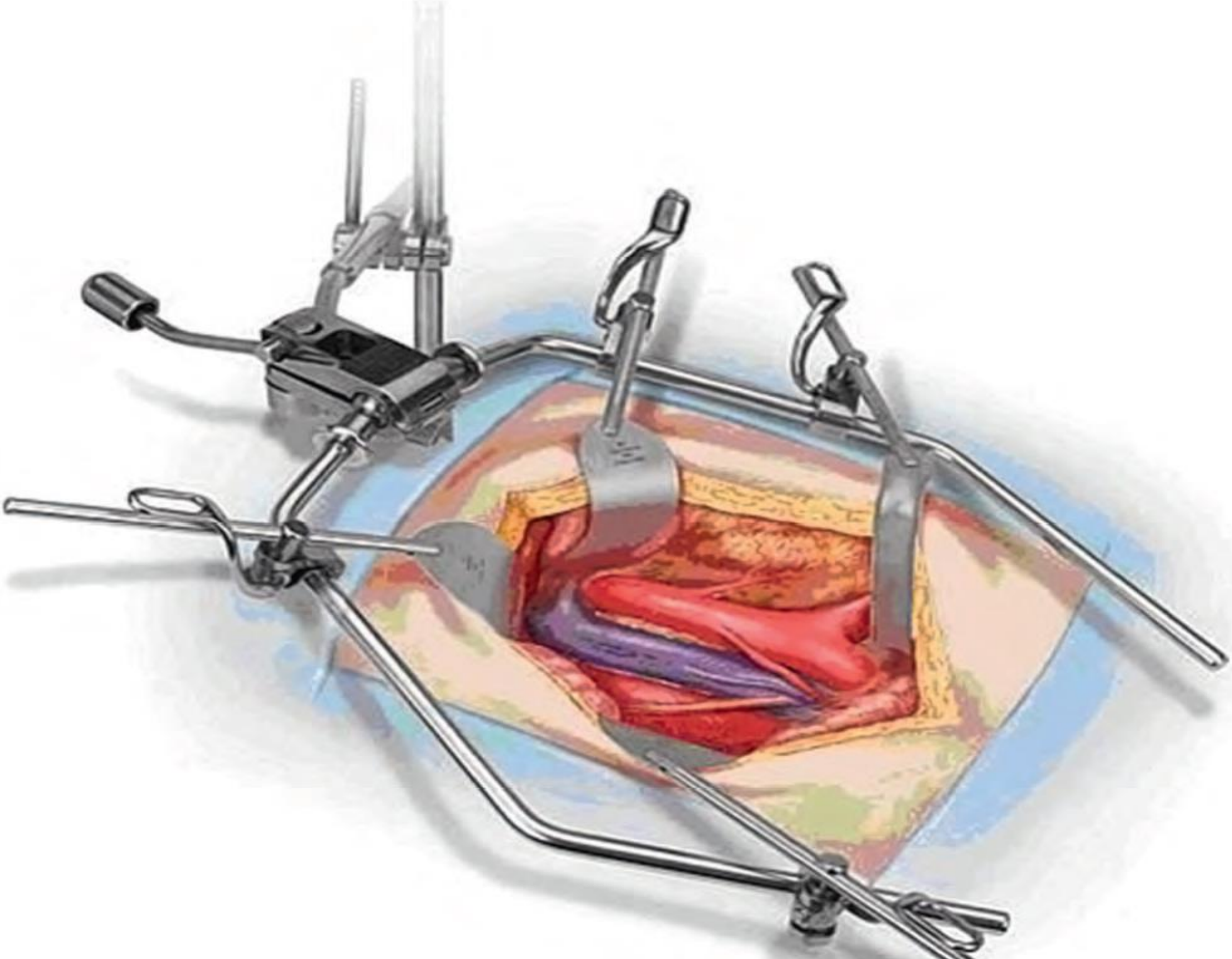




Retractors

The Omni-Flex vascular retractor (Omni-Tract Surgical, St. Paul, Minn) is frequently used for open aortic surgery, whether transabdominal or retroperitoneal.

A wide, fence-shaped blade is typically used to retract the small bowel during aortic dissection, and a narrow, deep blade may be used to retract the left renal vein cephalad.



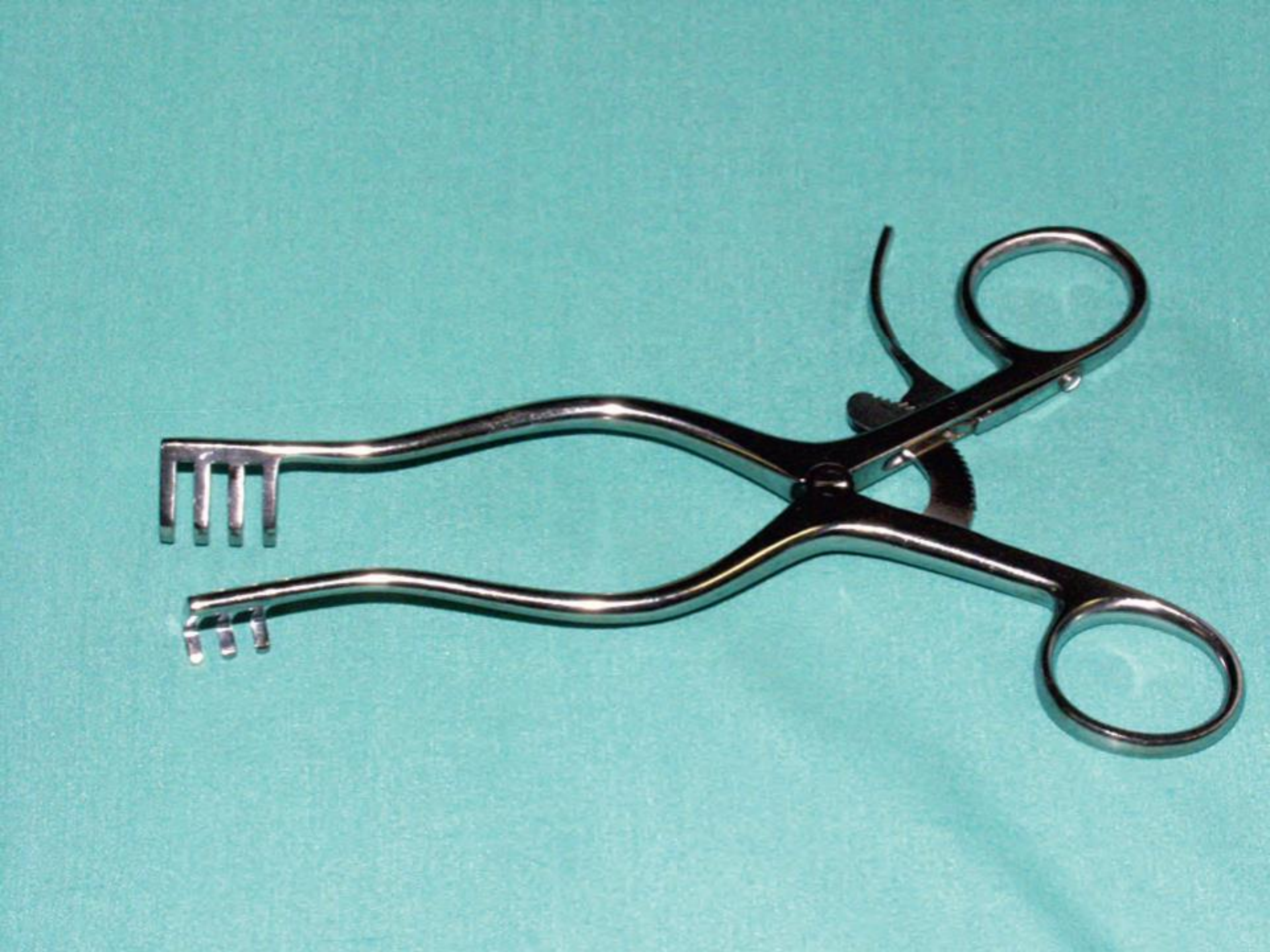
The **Weitlaner** retractor is commonly used for inguinal and popliteal incisions.

The Adson cerebellar retractor is angled such that it can also be very useful in groin and below knee exposure. In obese patients with significant inguinal pannus.

a **Miskimon** retractor can be especially useful because of its deeper and wider blades, which provide a larger retracting area.

Spring retractors are extremely useful when conducting infrageniculate vessel exposure because they tend to occupy little space.

The **Gelpi retractor** is typically helpful when conducting a first rib resection through a transaxillary approach for thoracic outlet obstruction.



Sutures

Commonly used monofilament sutures include polypropylene, polybutester, and polytetrafluoroethylene (PTFE).

Polypropylene sutures (Prolene, Ethicon Inc., Somerville, NJ; Surgipro and Surgilene, Covidien, Mansfield, Mass) are made of a monofilament strand of synthetic linear polyolefin.

These sutures tend to maintain their tensile strength over time. They have little friction and excellent handling characteristics.

They are widely popular and are probably the most commonly used suture material in vascular reconstructions.

PTFE sutures were developed to minimize the needle hole bleeding that is often seen when polypropylene sutures are used with PTFE grafts or patches.

They are designed so that there is minimal difference in the diameters of the needle and the suture. They have excellent handling characteristics, with a low tissue friction and low drag coefficient.

The needle and suture sizes vary, depending on the vessel.

For arterial anastomoses, the following suture and needle sizes are recommended:

2-0 or 3-0, **aorta**; 4-0, **iliac arteries**; 5-0, **axillary, common carotid, common femoral, and superficial femoral arteries**; 5-0 or 6-0, **internal carotid, popliteal, and brachial arteries**; 7-0 or 8-0, **tibial and inframalleolar arteries.**

Vascular exposure and technique

“Redo” Vessel Exposure

“Redo” vascular exposure poses a unique challenge, given the fibrous obliteration of the normal anatomic vascular planes.

When the surgeon is faced with a “redo” operation, sharp dissection with a No. 15 knife blade may allow better management of the scar tissue than scissor dissection, and it may allow the surgeon to stay in the appropriate dissection plane.

The most common vessel that requires “redo” exposure is the common femoral artery, and the approach to this vessel is illustrative of “redo” vessel exposure in general.

The principle of dissecting from known to unknown can be useful in preventing branch vessel injury during re-exposureand to obtain proximal control outside of the scarred area to aid in vascular control should an inadvertent injury occur.

Asignificant concern with a “redo” femoral artery exposure is injuring the profunda femoris artery.

Consequently, the superficial femoral artery is exposed in the most distal part of the incision, where minimal scarring exists.

The dissection is then carried along the medial aspect of the superficial femoral artery and progresses proximally.

Typically, the common femoral vein is identified during the process, revealing a safe dissection plane.

Once the inguinal ligament is reached, the common femoral artery is encircled with a loop.

The direction of the dissection is then reversed and continued back distally toward the superficial femoral artery.

The area of size transition between the common and superficial femoral arteries exposes the location of the profunda femoris artery.

At that level, dissection from the medial and posterior aspect of the common femoral artery identifies a plane that has not been violated and allows dissection of the profunda femoris artery from underneath the common femoral artery.

In cases of extensive scarring, the profunda femoral branch can be controlled with a balloon occlusion catheter after common femoral arteriotomy, to avoid potential injury during profunda dissection.

Blood Vessel Control

- Vascular Clamping
- Balloon Occlusion
- Vessel loops
- Pneumatic compression
- Other techniques

Vascular clamping

Ideally, vascular clamps should be applied to a disease-free segment of the artery.

Palpating the artery against a right angle clamp can help determine the presence and extent of atherosclerotic plaque, which is often in a posterior location and not appreciated by only palpating the anterior aspect of the artery.

If clamping is necessary across an area of diseased artery, the clamp should be applied in a manner that opposes the soft part of the artery against the plaque without causing plaque fracture or vessel tear.

Balloon Oclussion

If the plaque is circumferential or occupies more than 50% of the circumference, vascular clamps can fracture the plaque or tear the wall, and may not provide vascular control.

This can be managed by occluding the artery from within using a compliant balloon occlusion catheter, such as the Fogarty catheter normally used to perform embolectomy, or a noncompliant balloon catheter used for angioplasty.

There are also several compliant occlusion balloons that can be used to occlude the aorta during ruptured aneurysm repair, including Reliant (Medtronic, Minneapolis, Minn), Coda(Cook, Bloomington, Ind), and Equalizer (Boston Scientific,Natick, Mass)..

Balloon occlusion can be used to control the external iliac artery in the presence of extensive calcification
that extends beyond the most proximal part of
the exposure.

It is also useful for controlling the right common iliac artery during a left retroperitoneal abdominal
aortic aneurysm repair, the profunda femoris artery during repair of a pseudoaneurysm of a femoral anastomosis, or the renal or visceral vessels during a thoracoabdominal aortic aneurysm repair.

Vessel Loops

Vessel loops are ideal for controlling small- to medium-sized vessels, such as the profunda femoris or popliteal arteries and arterial branches.

Silastic vessel loops can be traumatic, however, if excessive tension is applied to them.

Pneumatic compression

A pneumatic tourniquet can be used for vascular control in the extremities and is ideal for infrapopliteal reconstructions.

It allows for minimal exposure, dissection, and handling of the arteries, and may decrease the risk of spasm or injury caused by clamping of the tibial vessels.

THROMBECTOMY AND THROMBOEMBOLECTOMY

Thrombectomy Catheters:

The standard ones are balloon catheters that vary in size, length, and maximal balloon inflation.

These catheters are typically available in sizes from 2 to 7F. Saline solution is used to inflate the balloon, except for the 2F balloon, which requires air insufflation for easy deflation.

The diameter of the fully inflated balloon is 4 mm for the 2F catheter, 5 mm for the 3F, 9 mm for the 4F, 11 mm for the 5F, 13 mm for the 6F, and 14 mm for the 7F.

Size 2F catheters are typically used for very small pedal or hand vessels. The most commonly used catheters are 3 to 5F catheters.

A 3F Fogarty catheter is typically used for tibial vessels.

A 4F Fogarty catheter is used for vessels the size of the superficial femoral and popliteal arteries; it can also be used for external iliac arteries.

A 5F Fogarty catheter is typically used for external iliac or common iliac arteries.

Size 6F and size 7F catheters can be used for thrombectomy of an aortic femoral graft or a saddle aortic embolus. A venous thrombectomy catheter with a large, lower pressure balloon is also available.

Arteriotomy Location and Shape

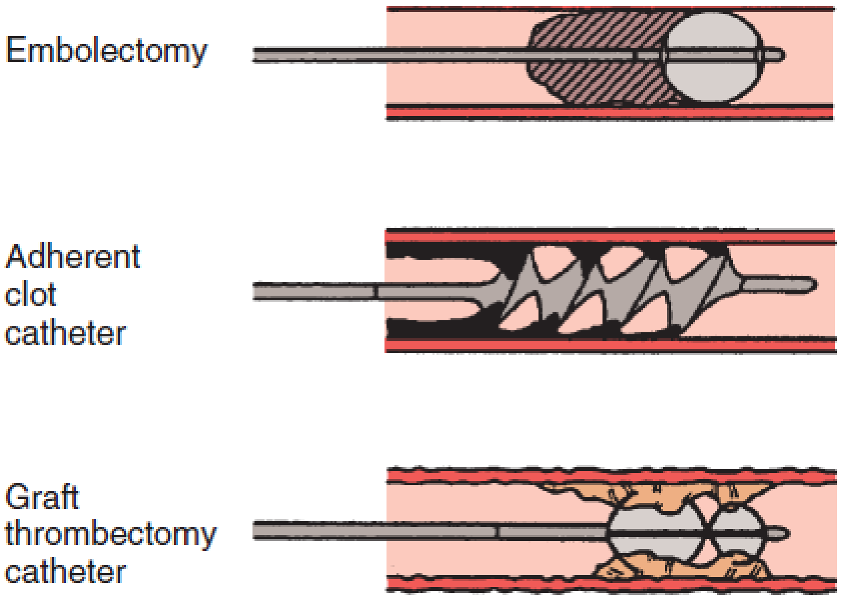
The selection of a transverse versus longitudinal arteriotomy for catheter access is influenced by the size of the vessel, the cause of the embolus or thrombus, and the presence of plaque in the vessel.

A transverse arteriotomy is usually simpler to close and may be preferred when dealing with an embolic process. When the occlusive pathology is due to an atherosclerotic and thrombotic process, or when significant arterial plaque is present, a longitudinal arteriotomy should be used.

In such a situation, it is not uncommon for an emergency bypass to become necessary, and the longitudinal arteriotomy can be incorporated into one of the anastomoses.

If a bypass is deemed unnecessary, a patch is usually needed to close the longitudinal arteriotomy to avoid significant narrowing of the vessel lumen.

Transverse arteriotomy can be easily closed with interrupted sutures to avoid purse-stringing and narrowing of the lumen of the artery at the site.



e-Figure 87-26 Thromboembolectomy catheters.

It is important to ensure that the catheter is being advanced intraluminally.

It can inadvertently pass in a subintimal plane, and inflation and withdrawal of the catheter in that situation can cause arterial dissection or disruption.

Injury is also possible because the procedure is commonly performed blindly or without fluoroscopic control.

Another cause of injury is overinflation of the balloon catheter and its withdrawal; this can result in significant shearing of the intima, with intimal disruption and damage.

To minimize vascular injury during balloon thromboembolectomy, several steps are necessary.

Selection of an appropriately sized thromboembolectomy catheter is a must .

Depending on the anatomy and the presence of scarring, bleeding may be excessive if finger control is used while passing the Fogarty catheter through the proximal artery. In
such situations, use of a Fogarty soft-jaw clamp is recommended.

The soft jaws are intended to appose the blood vessel walls just enough to prevent bleeding and still allow the thromboembolectomy catheter to be advanced or withdrawn.

Another helpful maneuver is to externally measure the distance from the arteriotomy to the location of the thrombus.

This helps determine whether the catheter has reached its desired destination. In addition, it may help limit unnecessary pushing of the catheter beyond the thrombus.

The inflation, deflation, and withdrawal of the balloon should be a dynamic and variable process to accommodate changes in vessel caliber.

To avoid leaving behind clinically significant thrombus,the reperfused limb or organ is carefully examined following arteriotomy closure. An angiogram may be obtained if the reperfusion does not appear satisfactory.

Endartrectomy

These include

- Open,
- Semiclosed eversion,
- Orificial
- Extraction endarterectomy.

Open endartectomy

In the open endarterectomy technique, the artery is opened longitudinally at the site of disease. The plaque is then separated from the artery wall in the direction of the arteriotomy and removed .

The arteriotomy can be closed primarily or with a patch. Being in the right anatomic vessel wall plane is essential to performing an adequate endarterectomy.

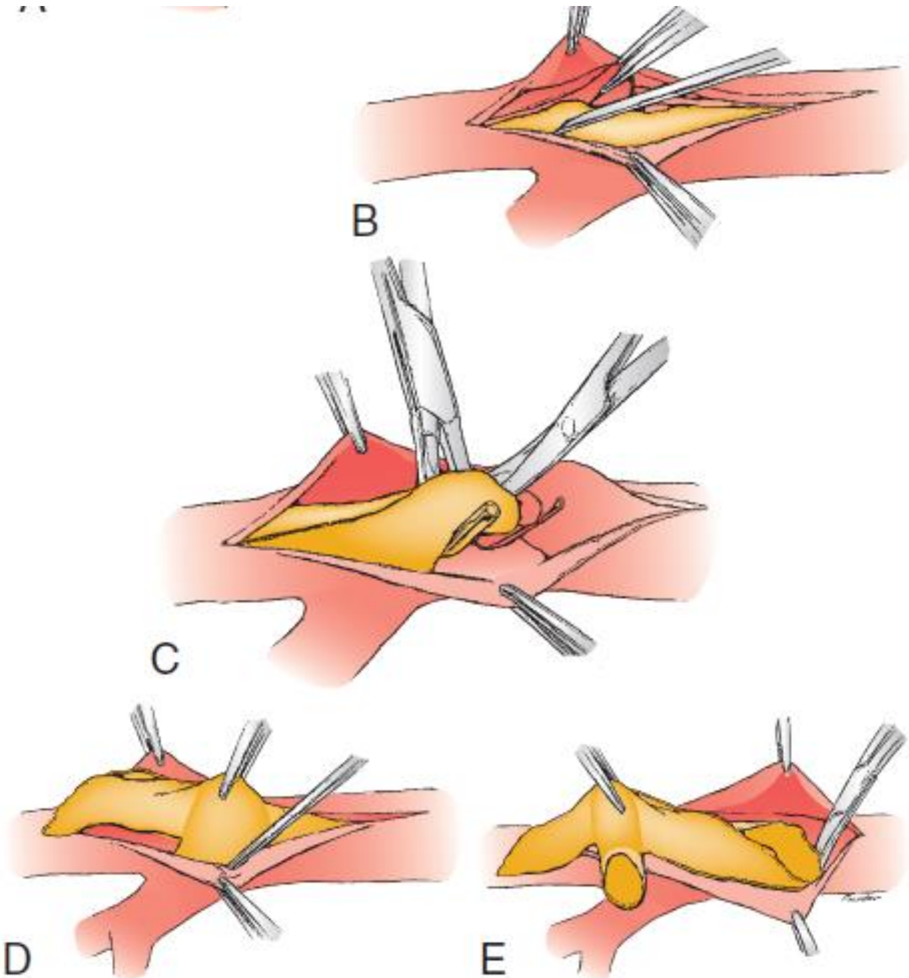


Figure 87-32 A–E, In the open endarterectomy technique, the vessel is opened longitudinally at the site of disease. The plaque is then separated from the vessel wall in the direction of the arteriotomy and removed.

Semiclosed Endartrectomy

The semiclosed endarterectomy was designed to avoid opening the artery longitudinally for the full extent of disease and thus circumvent a long arteriotomy closure.

Typically, the artery is opened in a proximal and a distal location. The plaque is first dissected and transected at the proximal level; then, it is cored out as a cylinder from the intervening segment with special ringed intra-arterial strippers, transected again at the level of the distal arteriotomy, and removed .

With this technique, closure of what would have been a long arteriotomy is replaced by closure of two small arteriotomies, one proximally and one distally.

In one modification of the semiclosed technique, only one incision is made in the artery. The plaque is crushed manually or with the help of a clamp at the other end, eliminating the need for the second arterial incision, which is usually used to transect the plaque.

Moll ring cutters allow sharp transection of the plaque from the remote site (Fig. 87-35), hence, the term remote endarterectomy. The disadvantage of this technique is the unpredictability of the endpoint.

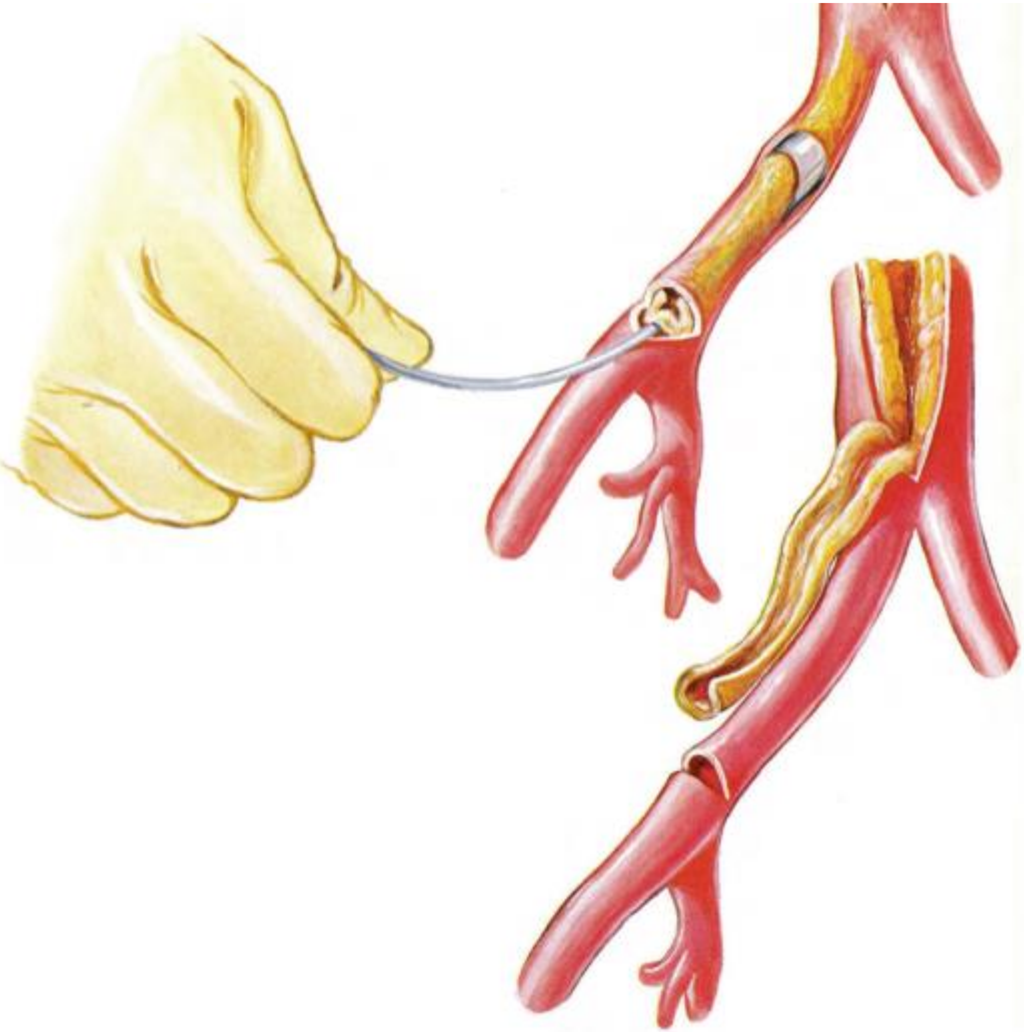


Figure 87-34 Plaque is cored out as a cylinder from the intervening segment, with the help of special ringed intra-arterial strippers.

In the eversion technique, the artery is transected, and the vessel wall is everted. The outer layer of the blood vessel,which includes the adventitia and part of the media, is held with forceps and gently lifted away from the plaque.

The plaque core is developed circumferentially and held firmlywith the forceps.

As the plaque is being extracted from the artery, the adventitia is retracted backward, and the artery is pushed forward from within, causing the plaque to protrude and be separated from the outer arterial media and adventitia (Fig. 87-36).

It is then transected when an appropriate endpoint is reached. This technique requires mobilization of a good segment of the proximal artery to allow eversion.

ARTERIOTOMY CLOSURE

- **Primary Closure**

Most transverse arteriotomies in nondiseased arteries can be closed primarily. This can even be done in smaller arteries measuring 2 mm in diameter, such as a radial or posterior tibial artery.

Similarly, primary closure can be performed in longitudinal incisions if the vessel is not diseased and has a diameter greater than 5 mm.

Patch Closure

When primary closure is expected to cause significant luminal narrowing of an arteriotomy, patch closure should be performed.

There are also data to support patch closure to improve the results of carotid endarterectomy.

Several technical and nontechnical factors may play a role in the decision to perform patch closure.

Technical factors include an artery less than 5 mm in diameter, the presence of significant atherosclerotic plaque at an arteriotomy site, a jagged arteriotomy,or a very tortuous artery.

Nontechnical factors include risk factors that predispose to restenosis, such as hyperlipidemia, heavy smoking, female gender, and a history of recurrent stenosis.

REPLACEMENT AND BYPASS PROCEDURES

- **End-to-Side Anastomosis**

An important step in constructing an end-to-side anastomosis is to align the vessels without a twist or kink. Anastomotic failure is more likely to be caused by technical imperfections than by the dimensions of the anastomosis.

The anastomosis should be prepared, such that the posterior incision in the conduit is parallel to its long axis; otherwise, a buckle effect may develop at the anastomosis.

Some recommend that the length be twice the bypass diameter.

Others recommend an arteriotomy greater than 2 cm.

In coronary artery vein bypass, a short arteriotomy (4 to 6 mm) is usually recommended.

Most often, an arteriotomy measuring 1.2 to 2 times the graft diameter is created.

An arteriotomy shorter than 1.2 times the diameter of the conduit results in the bypass's joining the artery at an unfavorably sharp angle. Too long an arteriotomy requires more time for construction, with no proven additional benefits.

An end-to-side anastomosis can be performed using an anchor or parachute technique.

Anchor Technique

In the anchor technique, the anastomosis is constructed by first placing a suture at the heel of the conduit and the arteriotomy.

The suture is tied, thus stabilizing and anchoring the conduit at the heel of the anastomosis.

Suturing is continued on one side of the heel to the toe, then halfway down the other side of the anastomosis.

The anastomosis is completed by suturing the other end of the heel suture until it meets the previously placed suture (Fig. 87-44).

An alternative is to start another suture at the apex and run it in a continuous manner on both sides of the apex toward the heel to complete the anastomosis tying the suture on both sides about the middle of the arteriotomy.

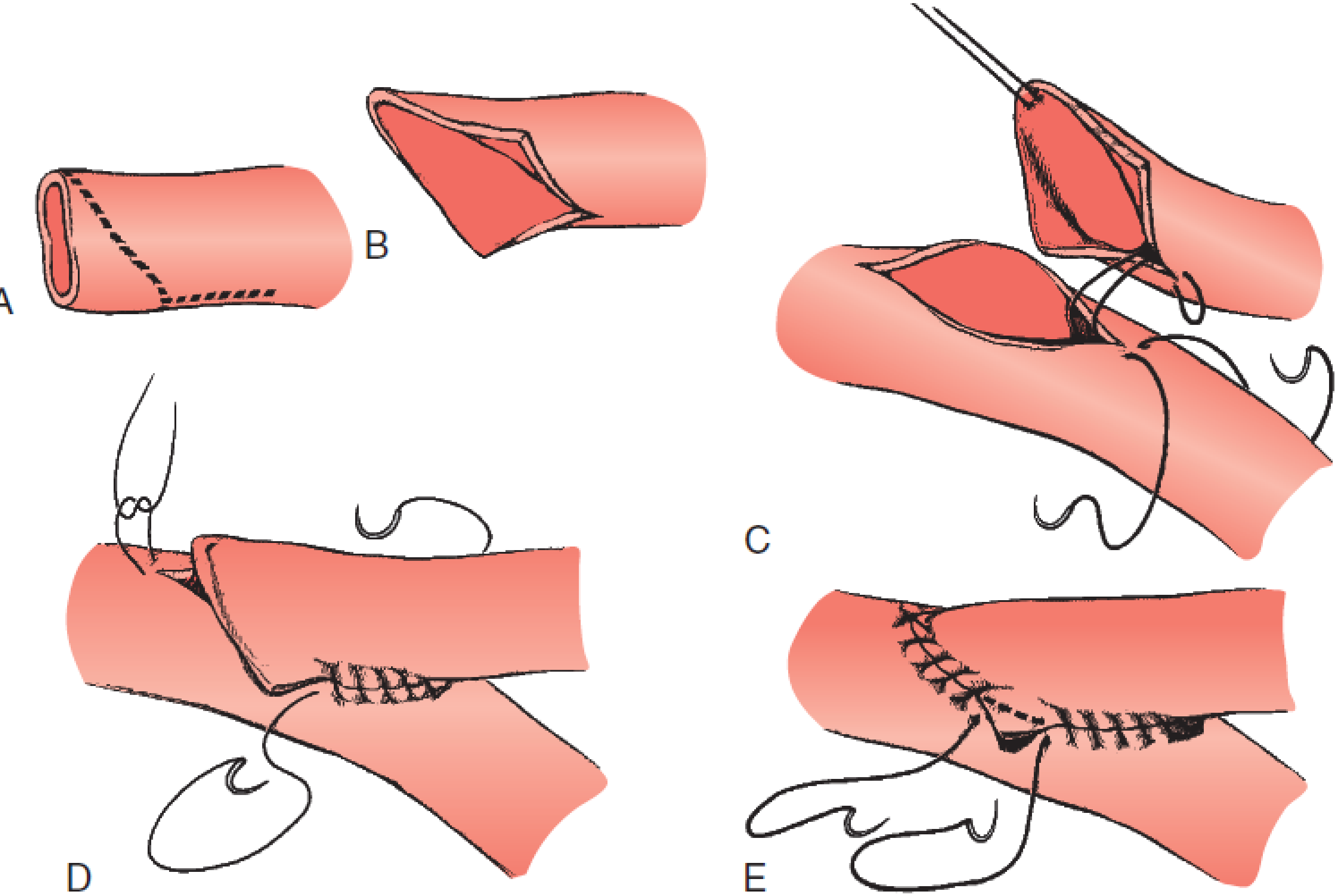


Figure 87-44 **A–E,** End-
tomosis anchor techniqu

The anchor technique is ideal for superficial vessels and larger arteries. The anchoring sutures facilitate traction and countertraction during the anastomotic procedure.

Parachute Technique

In the parachute variation of the end-to-side anastomosis,the sutures at the heel and the apex are not initially pulled down or tied. Suturing is started a few millimeters from the center of the heel.

The conduit is typically held with forceps a few centimeters from the arteriotomy. This allows the placement of sutures in deep areas without the conduit obscuring or interfering with suture placement..

First, several bites are placed in the conduit and the arteriotomy until the challenging part of the anastomosis is completed. This usually requires a total of three sutures on each side of the center of the heel.

Tension is then applied on both ends of the suture, and the bypass is slowly pulled toward the anastomosis, achieving a tight suture line (Fig. 87-45).

It is important to avoid excessive, continuous pulling on the suture line during this step because it could result in tearing of the arterial wall

The parachute technique is especially useful if the vessels are small or in a deep location where visualization of the first few bites at the apex and heel may be suboptimal.

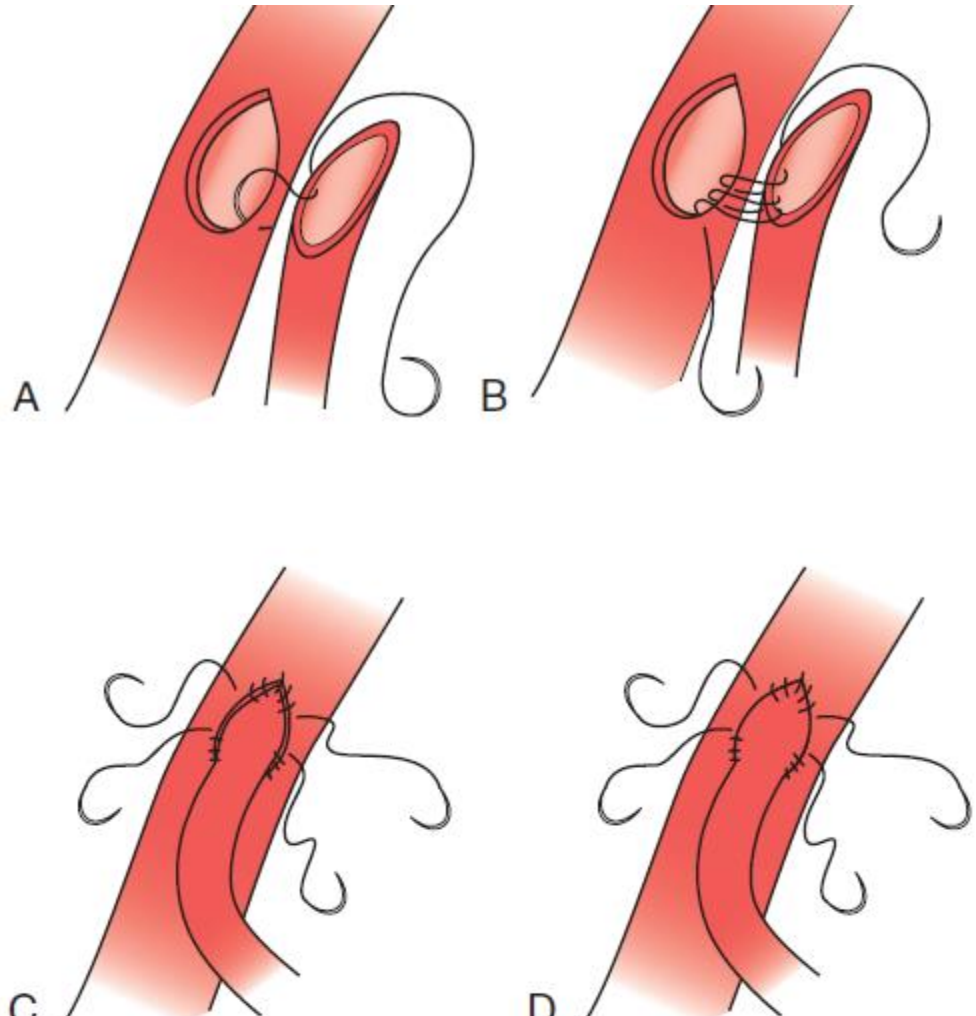


Figure 87-45 A–D, Parachute technique—another variation of the end-to-side anastomosis.

End-to-End Anastomosis

An end-to-end anastomosis is typically performed for replacement of an arterial segment, such as an aneurysmal artery or a vessel that has been transected by trauma.

The technique varies, depending on the size of the vessels and their mobility.

One technique involves placing two diametrically opposed sutures in an anterior and posterior part of the vessel. The sutures are tied, and the anterior part of the anastomosis is constructed first.

The vessels are then flipped 180 degrees, placing the posterior wall in an anterior location for completion of the anastomosis (Fig. 87-46).

When constructing an end-to-end anastomosis between two small vessels, it is essential to spatulate the anastomosis to avoid compromising the lumen.

Thus, both segments are transected in an oblique manner, and the incision is extended posteriorly.

Side to side anastomosis

A side-to-side anastomosis is rarely performed. It can be used, however, to create a side-to-side radiocephalic arteriovenous fistula for chronic hemodialysis or a side-to-side arteriovenous fistula distal to an infrainguinal prosthetic bypass as an adjunctive procedure to improve graft patency by decreasing outflow resistance.

The anastomosis is created by longitudinal arteriotomy or venotomy where the walls come in direct contact.

The posterior wall of the anastomosis is typically constructed first. The anastomosis is usually 6 to 10 mm long.

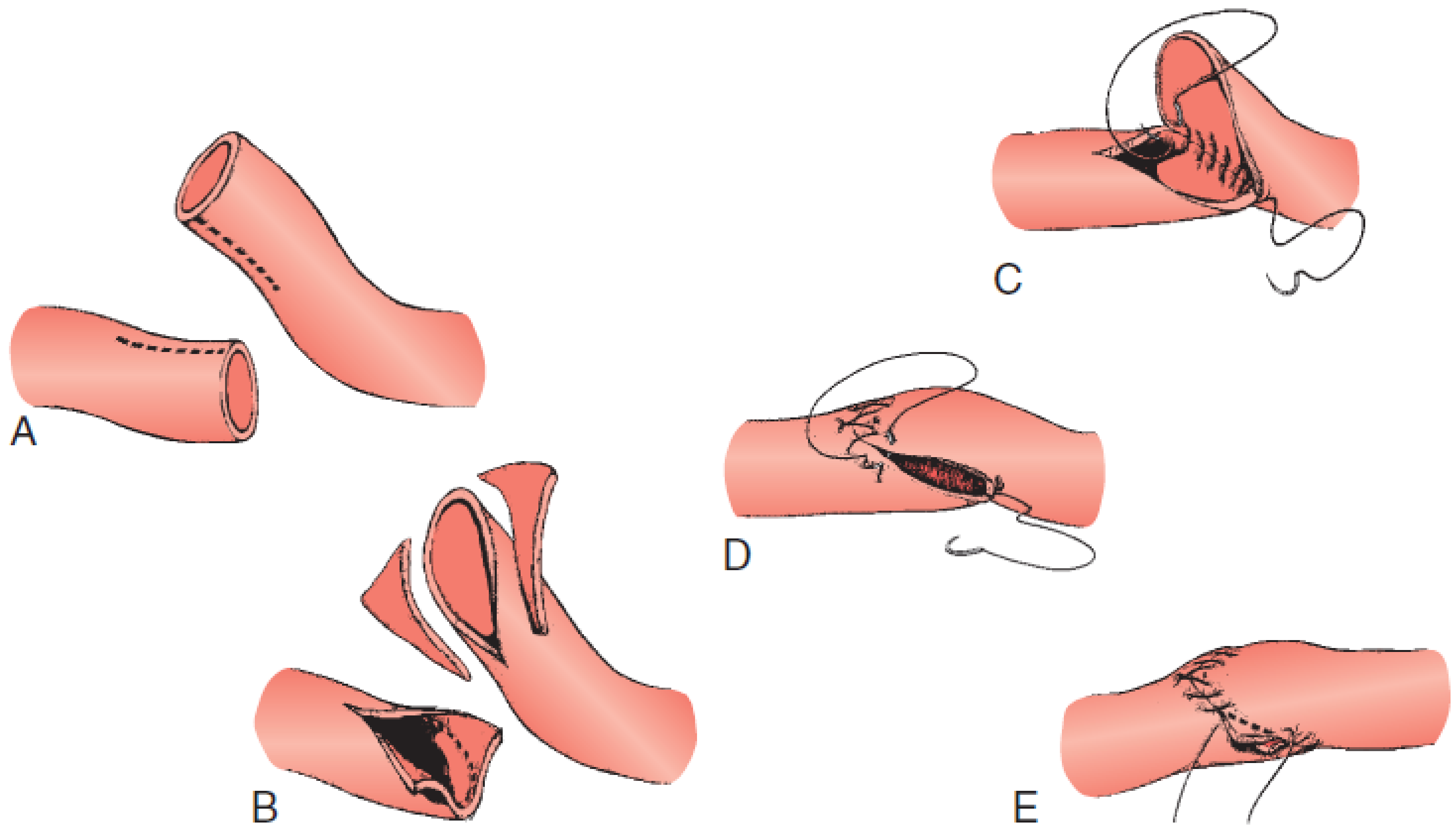


Figure 87-49 A-
end anastomosis
vessels.

Adjunctive Techniques for Infrainguinal Bypass Anastomosis

T-Junction

A useful technique to facilitate the construction of an anastomosis in infrainguinal vein bypass is the T-junction technique (Fig. 87-50).

In this method, a side branch in the vein is identified. The vein is transected 5 to 10 mm from the branch and then slit along the posterior wall in a fashion to incorporate the side branch in the anastomosis.

The shape of that segment of vein looks like a "T."

This can be used at the proximal or distal anastomosis and is helpful in minimizing sharp angulation of the bypass and narrowing at the heel of the anastomosis.

Saphenofemoral Junction Vein Cuff

When constructing a greater saphenous vein bypass, the vein can be transected at the saphenofemoral junction with a 1-mm rim of femoral vein (Fig. 87-51).

This technique provides a large venous hood for construction of the anastomosis,especially if the artery is thickened and the vein is relatively small.

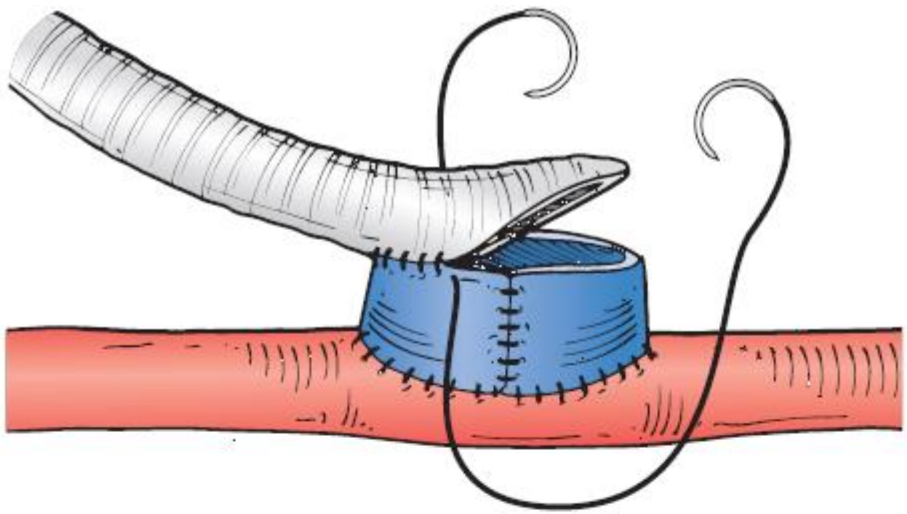


Figure 87-52 Venous cuff at the distal anastomosis of prosthetic grafts.

The Taylor patch technique requires a long arteriotomy (3-4 cm) so that the patch can be constructed longer than the diameter of the prosthetic conduit (Fig. 87-53).

A U-shaped slit approximately 1 cm in length is made on the underside of the graft with minimal angulation to ensure that the graft lays almost parallel to the artery.

The heel of the graft is then sutured directly to the proximal portion of the arteriotomy with the suture line continued along each side of the arteriotomy.

The anterior surface of the graft is then incised parallel to the arteriotomy to a point 2 cm proximal to the heel of the anastomosis.

A vein patch varying from 5 to 6 cm is used to close this elliptical defect. The patch begins distally on the artery with interrupted sutures and is completed proximally onto the PTFE with a running suture.

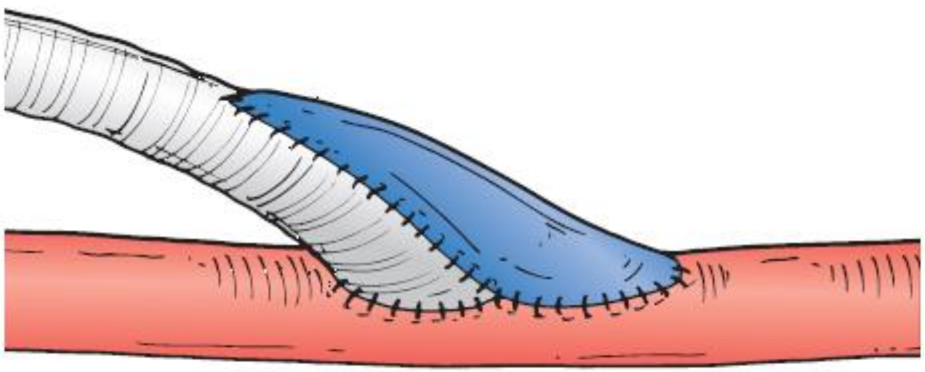


Figure 87-53 Taylor patch.

<u>The Saint Mary's boot</u> technique utilizes a similar arteriotomy and venous harvest as the Miller cuff; however, the corner of the venous segment is sutured to the apex of the arteriotomy to form the anastomotic toe (Fig. 87-54).

The remainder of the venous-arterial anastomosis is formed in a similar fashion to the Miller cuff; however, the redundant vein is excised obliquely and sutured to the longitudinal edge.

Next, a segment of the posterior collar is incised to increase the size of the anastomosis between the graft and vein collar.

Overall, the Saint Mary’s boot maintains a fully compliant venous collar, avoids any direct contact between the artery and graft, and maintains the hemodynamic advantages of theTaylor patch.

Its main drawback is the technical difficulty of its construction.

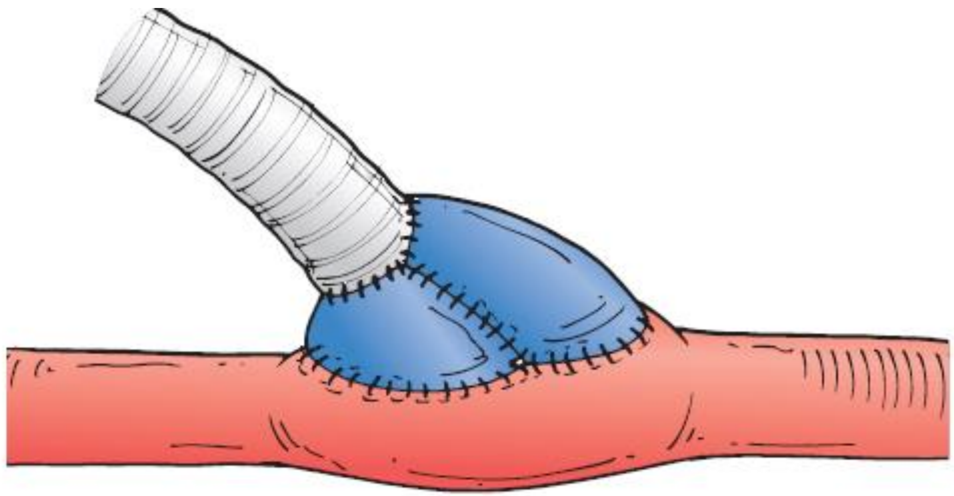


Figure 87-54 Saint Mary's boot

Thank You