PERFORMING THE DISTAL ANASTOMOSIS

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A thorough knowledge of coronary artery anatomy is essential to perform a quality distal anastomosis. Prior to induction of cardiac arrest, the coronary arteries should be examined and correlated with angiographic images. Coronary arteries follow an epicardial course and are often located beneath the fatty tissue surrounding the heart. Coronary arteries may appear as silhouettes at certain points beneath the adipose tissue, and exploration begins at the point where the coronary artery is seen and progresses toward the target area. Palpation is another method besides inspection. Digital exploration attempts to palpate coronary calcifications and previous stents, providing an idea of the location of more proximal portions of the coronary artery. In cases where the coronary artery is completely intramyocardial and, despite all efforts, the relevant coronary artery cannot be explored, a small transverse arteriotomy is performed at the most distal point. A retrograde probe is, then, passed through this arteriotomy to determine the location of more proximal segments of the coronary artery. Next, the distal arteriotomy is primarily repaired. While determining the target area for the anastomosis on the coronary artery, care should be taken to avoid being distal to the stenotic region. In addition, efforts are made to identify a site free of atherosclerotic plaque and calcification to ensure the quality and long-term patency of the distal anastomosis.

After identifying the target area for the anastomosis, the epicardium and adipose tissue are dissected longitudinally with a #15 scalpel. If there is excess tissue on the coronary artery, a fat retractor can be used during anastomosis, or excess tissue can be sutured with 5/0 suture for convenience. Once the superior wall of the coronary artery is clearly visualized, a small arteriotomy is made with an ophthalmic or No. 11 scalpel positioned centrally over the coronary artery. Care must be taken while performing a central arteriotomy to avoid inadvertently cutting the posterior wall of the coronary artery. Sometimes, due to excessive venting, the anterior and posterior walls of the coronary artery may be adhered during arteriotomy. To prevent this, venting is stopped or a small amount of cardioplegia is given to ensure that the lumen of the coronary artery is filled. The arteriotomy is, then, performed safely. If the posterior wall of the coronary artery is inadvertently cut during the arteriotomy, it should not be left as is. A U-stitch is passed through the incision, exiting the coronary artery, and tied on the ventricular anterior surface to prevent progression of the cut to the posterior wall, avoid dissection, and prevent intramyocardial hematoma. Particular care should be exercised with thin vessels, as they are at risk of injury.

Ensure that the arteriotomy is advanced proximally and distally by entering the lumen precisely with appropriate angled Potts® scissors through the small incision on the artery. The size of the intended arteriotomy is adjusted to be at least 1.5 times the diameter of the relevant coronary artery. Simultaneously, the diameter of the conduit to be used should also be taken into consideration.

TROUBLESHOOTING

- After arteriotomy, if there is a significant amount of back-flow from the coronary artery, check the followings:

- Is the aortic vent functioning? May it be collapsed?
- Is the X-clamp securely placed on the aorta?
- Is venous drainage sufficient? Check the venous cannula.

Graft Preparation for Anastomosis

After removing the great saphenous vein from the leg, blood is injected through a syringe to ensure proper control of its branches. It is crucial to avoid applying excessive pressure at this stage. If there is a valve inside the vein, the tip should be advanced a few centimeters downwards to achieve a cleaner field for anastomosis. The end of the vein is cut obliquely (Figure 4.1a), the incision at the heel is extended somewhat (Figure 4.1b), and then the edges are trimmed to create a "cobra head" appearance (Figure 4.1c and d). This process ensures obtaining a vessel end which will smoothly extend over the arteriotomy.

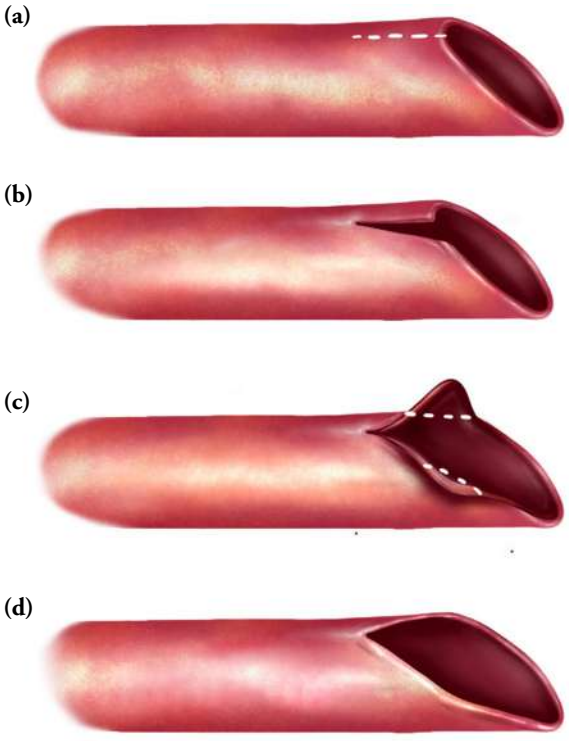


Figure 4.1. (a-d) After the graft is cut slightly obliquely, the incision is extended by a few millimeters. Subsequently, the sharp edges are trimmed to create a cobra head formation. Precision scissors with a 30-degree angle can be beneficial during these stages.

The previously prepared left internal thoracic artery (LITA) graft is retrieved from the thoracic cavity and extended over the heart. Following the path between the surgeon's first two fingers, starting proximally, any twists in the graft are corrected, and its position is adjusted, if necessary. The length of the LITA is set over the target area on the coronary, leaving some room, and the remaining distal part of the LITA is cut and discarded. The length of the LITA should be adjusted to avoid stretching the anastomosis. However, sometimes after completing the anastomoses and coming off cardiopulmonary bypass (CPB), when the lungs become hyperinflated, tension in the LITA may be noticed. In such cases, a 2 to 3-cm vertical incision is made, paying attention to the phrenic nerve, where the pericardium crosses the LITA, to gain distance. The second surgeon holds the LITA from both pedicles with a delicate forceps, stabilizing the hands by leaning them on the sternum retractor to prevent their shaking and the separation of the two pedicles. Then, the surgeon, using 90º scissors, opens the fascia and other tissues over the vessel starting 2 to 3 cm from the heel of the LITA. The LITA is widened 1 to 2 cm at the heel, with the incision in the middle. The diameter of the conduit is aimed to be 25 to 30% larger than the target coronary.

TIPS & PITFALLS

- Before delving into the technical details of the distal coronary anastomosis, it is reasonable to emphasize some fundamental principles:
  - Never grasp or hold the endothelium of the coronary artery or conduits with forceps. If it is unavoidable to hold the conduit endothelium with forceps, exclude that region from the anastomosis. Prefer the use of atraumatic forceps during the anastomosis process.
  - While grasping vascular structures with forceps, prefer holding from the adventitia.
  - Always pass through the layers of the vessel wall with the needle as a "full-thickness" pass; avoid tangential passes.
  - Avoid passing very fine or very deep stitches from both the conduit and the coronary artery.
  - Pay attention to adventitial fragments, adipose tissue, calcification, and other

foreign particles protruding into the anastomosis; if necessary, wash and aspirate to ensure they do not remain in the vessel.

- The direction of stitches passed through the coronary artery should be from the inside out (also to stabilize coronary plaques).
- Pull the needle through the "eyelet" appropriately while passing it through the graft or coronary; avoid grabbing the needle from the tissue with forceps without adhering to the eyelet.
- When the second surgeon pulls the thread, avoid applying excessive force to prevent tearing or breaking. Apply enough traction to prevent the thread from becoming loose.
- Pay particular attention while passing stitches through the heel and toe areas during the anastomosis, as these regions are crucial.

Distal Anastomosis Procedure

There are various anastomosis techniques described in the literature to date, which can be categorized into manually performed and automatically performed anastomoses. Distal anastomosis devices such as St. Jude Distal Anastomotic Device, Magnetic Vascular Positioner, Automated Anastomotic Distal Device, Coronary Anastomosis Coupler, C-port®, and U-clip® are some examples, although not detailed here. Anastomoses performed by the surgeon fall into two main groups: continuous suture technique and interrupted suture technique.

After all the preparations are completed, the anastomosis is initiated with full motivation. For coronary anastomoses, a commonly preferred suture is a 7/0 polypropylene with needles on both ends. If the target coronary artery or conduit is very thin, an 8/0 polypropylene suture may be used. In cases where the coronary artery is highly calcified, special sutures with designed needle structures (such as Prolene™ Visi-Black™; Ethicon®, NJ, USA) can be considered for facilitating the process. The angle of the anastomosis also plays a significant role in long-term patency. Both mathematical modeling and hemodynamic studies have suggested that for minimizing shear stress, the anastomotic angle should be narrower than 45 degrees. Additionally, for minimal turbulence, the optimal angle is around 30 degrees.

Distal Anastomosis with Venous Graft

In distal anastomosis performed with a venous graft, the end-to-side technique is most applied using the parachute method. Firstly, the method of seating the top of the anastomosis will be discussed. The previously prepared conduit is either delicately held by a second surgeon from the nose part without damaging the endothelium, or it is secured with a fine mosquito clamp. The needle of a 7/0 polypropylene suture, mounted on a straight (forehand) Castro needle holder, is passed from the inner to outer side about 3 to 4 mm before the top of the conduit (at 8 o'clock position). A rubber-shod clamp is placed on this needle. The other needle of the suture is used to continue the anastomosis. The second surgeon starts following by taking the loop of the thread and applying partial traction. The other needle is passed from the inside to the outside at the point corresponding to the coronary artery. It progresses toward the top in the opposite direction of the clockwise rotation of the conduit. The conduit is passed from the outside to the inside. Then, the anastomosis continues by passing from the inside to the outside of the coronary artery. Particular care should be taken to ensure that the distance between the stitches passed on both the conduit and coronary artery is the same. Whatever distance is covered on the conduit should be the same on the coronary artery. Any imbalance at this stage can lead to bleeding by forming an “ear” after the completion of the anastomosis. After passing one or two stitches at the top of the anastomosis, the conduit is brought closer to the coronary artery. The surgeon takes both ends of the polypropylene suture in both hands, and the second surgeon holds the conduit from the adventitia, applying gentle traction. The threads are wetted to facilitate sliding, and the surgeon slides by pulling both threads evenly, seating the graft on the artery. Care should be taken to avoid causing intimal tears by applying excessive traction. Also, it is crucial to ensure that the threads, particularly at the top, sit properly without being loose. The anastomosis is internally checked, and if such a situation has occurred, the stitches that have looped and not seated are strengthened by sliding. The top of the anastomosis is checked with a probe of suitable size for the vessel diameter. Caution should

be exercised while using the probe. It should be ensured that an appropriate-sized probe is selected and fully inserted into the lumen. Without careful attention, it should be kept in mind that it may cause coronary dissection and rupture. Subsequently, stitches are passed on the conduit from outside to inside and on the coronary artery from inside to outside, following the anastomosis. After passing the stitches on the nose part of the anastomosis, the stitches on the other side are passed. After passing the stitches on the nose part, the anastomosis can be carefully checked with a probe of suitable size for the vessel diameter. In cases where the target coronary is very thin, to prevent suturing the back wall or narrowing the vessel, a 1-mm probe can be placed inside the coronary artery lumen, and the nose part stitches can be passed in this way. Stitches on the side wall are completed, and after passing the last stitch, before tying, some cardioplegia is sent through the graft. Thus, washing to remove undesired things such as air, thrombus, and debris is ensured. Then, the threads are slid to take up the space, tied, and cardioplegia is continued to be delivered during this seating and tying stage. The main goal is to prevent the purse-string effect that may arise from excessive seating of the thread by the intravascular pressure created by the simultaneously delivered cardioplegia. The completion of the anastomosis is aimed with a total of 12 to 15 stitches. Later, the heart is brought to its anatomical position, and cardioplegia continues to be delivered through the conduit. Thus, the anastomosis is tested for the received flow and direction of bleeding, providing insights into the coronary distal bed (Figure 4.2).

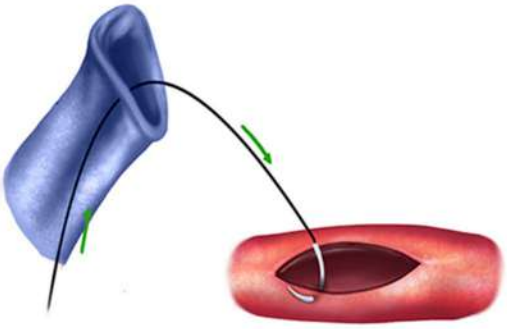
Another technique is the one where the nose of the anastomosis is seated first. This technique may be more suitable, particularly for anastomoses performed distal to the branches of the right coronary artery. In this method, the initial stitches are passed through the nose part of the anastomosis, and the conduit is brought closer to the coronary by sliding the threads. Then, the other needle is used, and the stitches progress over-and-over toward the top. After passing the stitches carefully on the top, they are tied with the other thread at 9 o'clock (Figure 4.3).

Distal Anastomosis with Arterial Graft

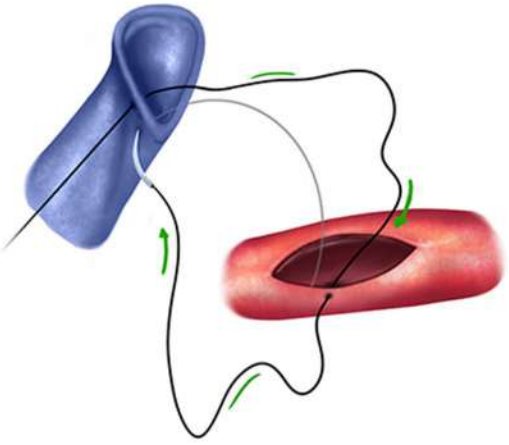
Since the most used arterial conduit is LITA, we will first discuss the LITA-left anterior descending artery (LAD) anastomosis. The technique for performing a coronary distal end-to-side anastomosis using the parachute method with an arterial graft is essentially the same as the method described above. The first stitch is passed from the inside to the outside in the conduit just before the top stitch, and a rubber-shod clamp is placed (Photo 4.1). The other needle is passed from the inside to the outside in the coronary artery. Then, continuing with this needle, stitches are passed from the outside to the inside in the conduit and from the inside to the outside in the coronary artery, passing through the top and then 1 to 2 more sutures. After a total of 4 to 5 stitches, the loop of the threads is carefully taken, and the LITA is lowered onto the coronary artery (Figure 4.4a and b) (Photo 4.2a-c). The remaining sutures are passed, totaling 10 to 12 stitches (Photo 4.3). Some surgeons, while preparing the LITA, leave a portion at its most distal end for the second surgeon to hold and do not include this part in the anastomosis. While reaching the nose part of the anastomosis, this part is cut off with Potts® scissors and discarded before continuing the anastomosis (Figure 4.4c). Thus, any potential mismatch between the graft opening and the coronary opening can be prevented. While coming to the other thread, the proximal and distal anastomosis can be gently checked with a 1-mm probe, and the bulldog clamp on the LITA is removed and deairing is provided with bleeding. The threads are tied (Figure 4.4d). The LITA graft is secured to the epicardium on both sides of its pedicle with 6/0 polypropylene sutures (Figure 4.4e). Since the LITA-LAD is usually the last anastomosis performed, it may be beneficial to remind perfusionists to warm the patient after starting the anastomosis. The right internal thoracic artery (RITA) is another conduit used as an arterial graft. It can be anastomosed to the distal coronary arteries of the right coronary or circumflex. If it is to be anastomosed to obtuse marginal branches, it should be passed through the transverse sinus and brought to the left side of the heart. Then, anastomosis is performed using the technique described above.

Sequential Anastomosis

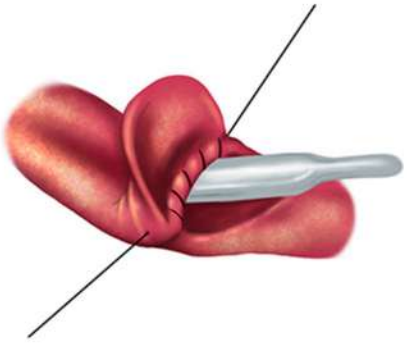
While the sequential anastomoses are technically performed based on the fundamental principles mentioned above, they have some specific intricacies. Sequential anastomoses can be beneficial in cases where complete revascularization is planned for patients with multiple vessels.



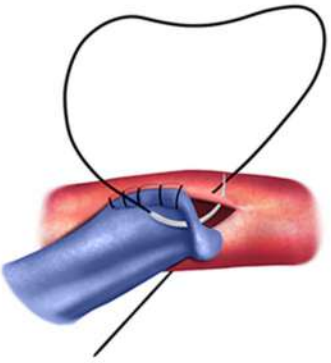
(a) Stepwise technique for a distal anastomosis



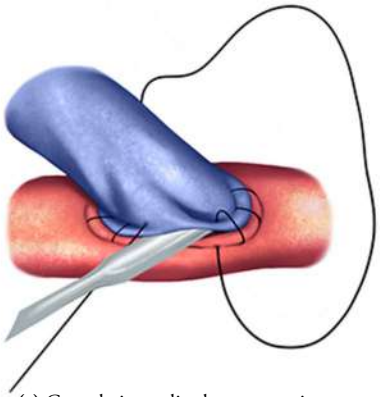
(b) Stepwise technique for a distal anastomosis



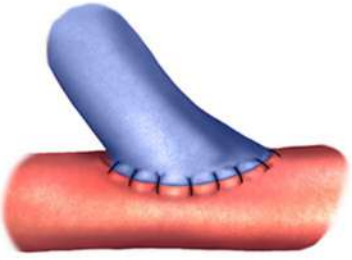
(c) Stepwise technique for a distal anastomosis



(d) Completing a distal anastomosis



(e) Completing a distal anastomosis



(f) Complete

Figure 4.2. Construction of the distal anastomosis. With this technique, the heel portion of the venous graft is first positioned toward the proximal end of the coronary artery incision (The figure sequence is from left to right, top to bottom).

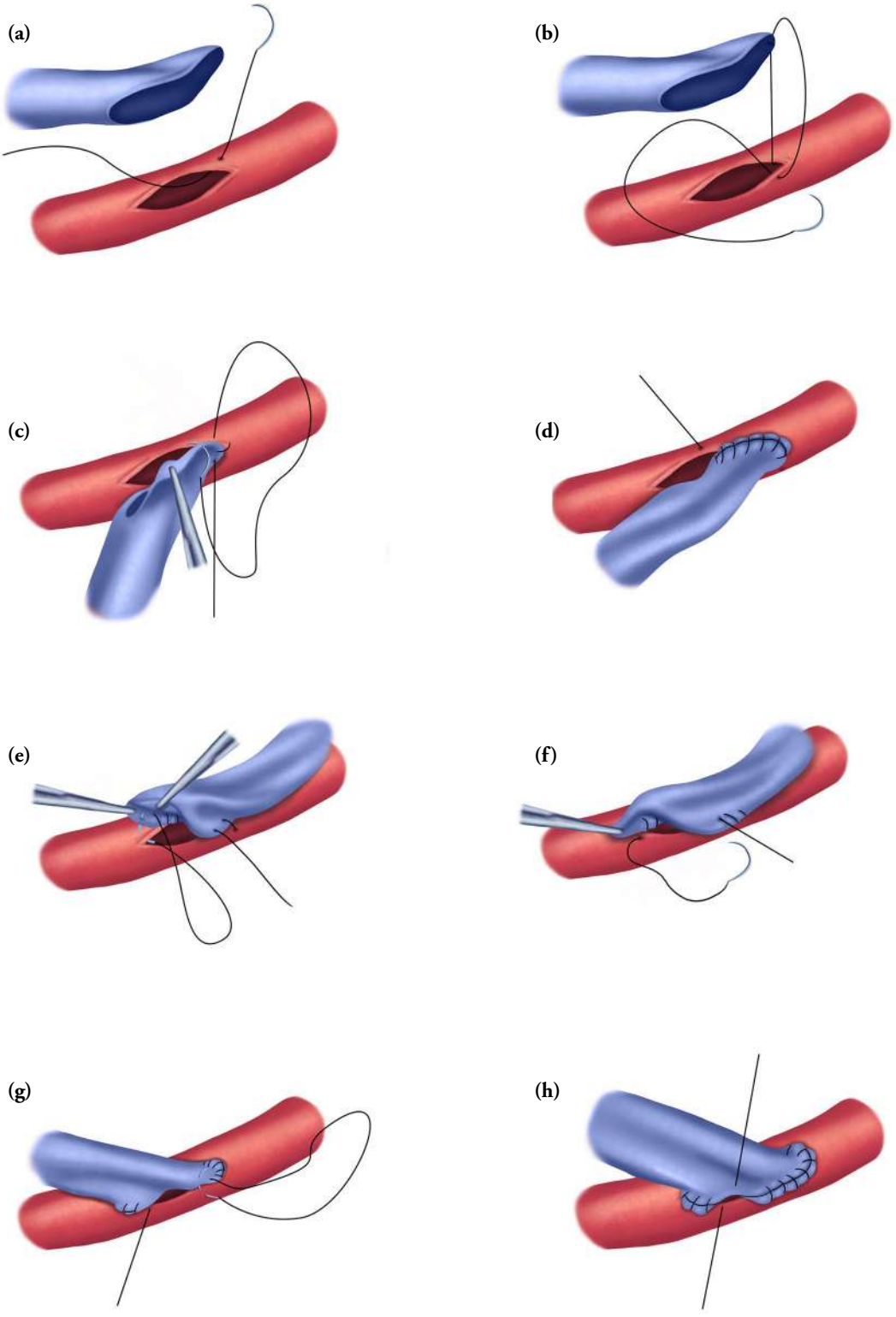


Figure 4.3. In this distal anastomosis technique, the graft (blue color) is positioned in such a way that the nose or tip aligns with the distal end of the coronary artery incision (The figure sequence is from left to right, top to bottom).

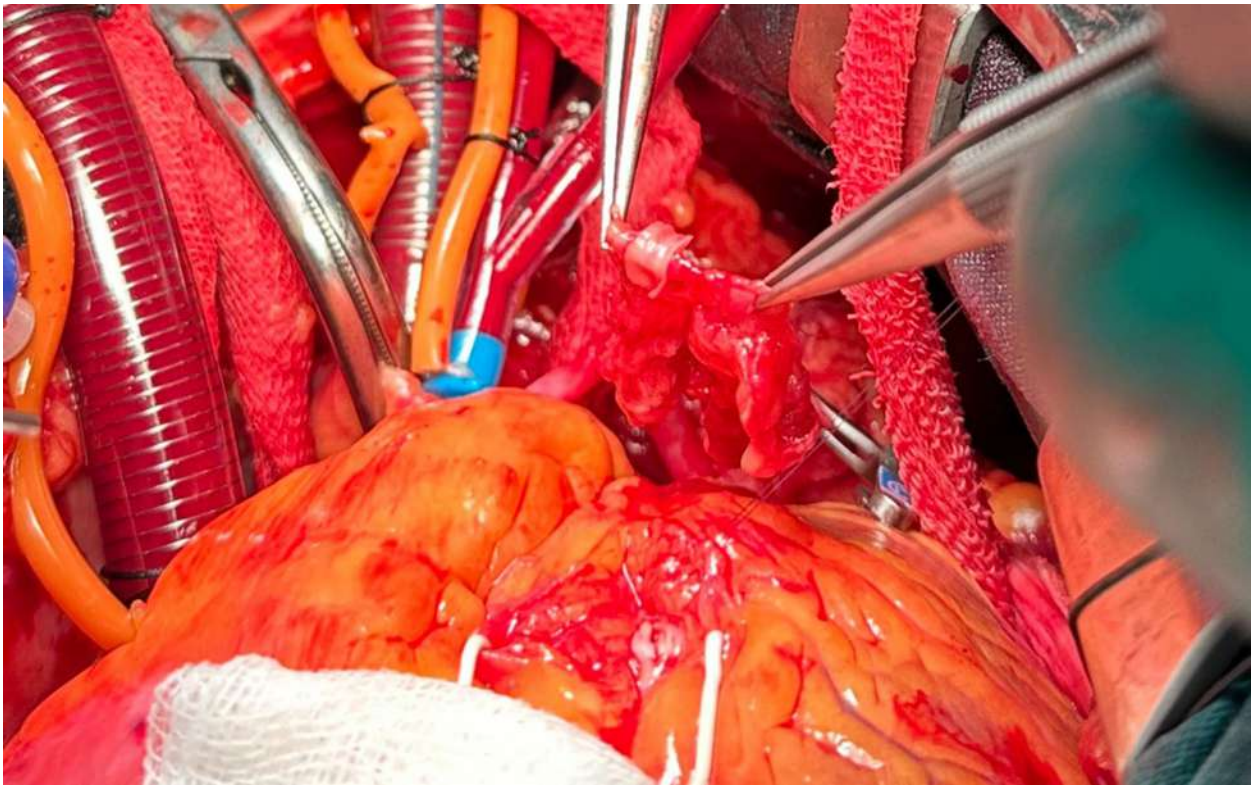


Photo 4.1. The left internal thoracic artery (LITA) graft is held by the assistant surgeon at the two ends of the pedicle, making the lumen of the artery visible. Since the left anterior descending artery (LAD) area is covered with epicardial fat tissue, a fat extractor has been used.

This technique is particularly useful when there is a lack of conduits or sufficient space for the proximal anastomosis, such as in short aortas or in the presence of calcification/plaques in the aorta.

It is essential to review the suitability of coronary anatomy for sequential anastomoses. Since the course of coronary arteries and the localization of lesions vary in each patient, the feasibility of sequential anastomosis should be evaluated based on these factors. The first anastomosis is performed using the standard method at the most distal site. Subsequently, with the heart filled, the length of the conduit is adjusted according to the location where the arteriotomy will be made on the target coronary.

During this stage, being meticulous and not leaving the graft too long or too short is of paramount importance. Shortening the graft threatens the anastomosis, while leaving it too long may result in graft kinking. The coronary arteriotomy is performed as described above. While performing sequential anastomoses, the arteriotomy should be made somewhat smaller. Different scenarios may arise concerning graft position and the incision to be made on the graft.

In cases where the graft and coronary artery run parallel to each other, the incision on the graft is made parallel to the long axis of the graft (Figure 4.5a). This makes adjustment easier, as the lengths of the incisions on the coronary artery and the graft are the same. This method can be preferred in sequential anastomoses using arterial grafts (Figure 4.5b).

In cases where the graft intersects the coronary artery perpendicularly, the incision on the graft can be made parallel or perpendicular to the long axis of the graft. When the diameter of the venous graft is sufficient, an incision can be made perpendicular to the graft (Figure 4.5c and d). However, if the diameter of the graft is small, be cautious as the anastomosis

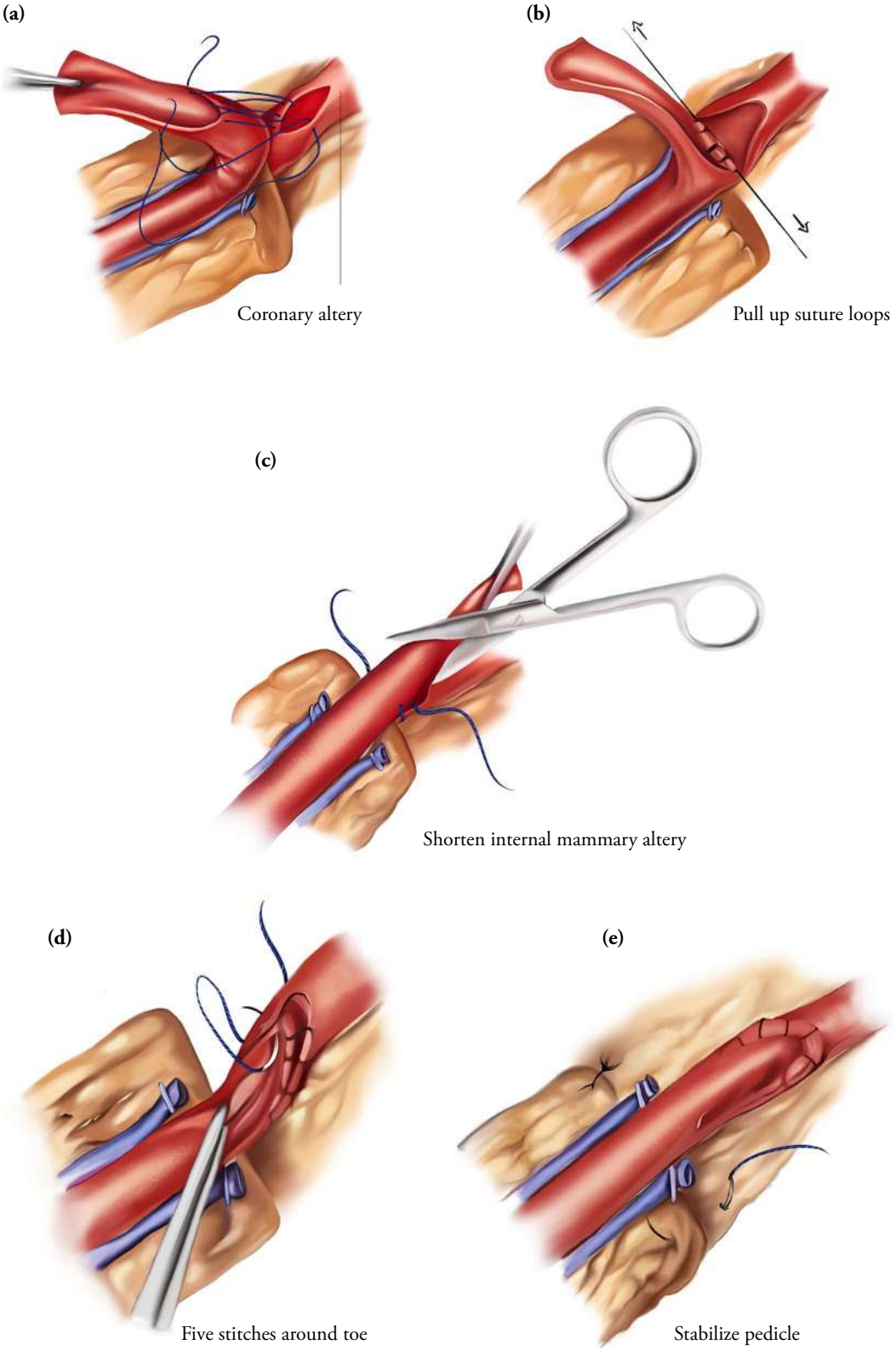


Figure 4.4. Anastomosis technique with arterial graft (The figure sequence is from left to right, top to bottom).

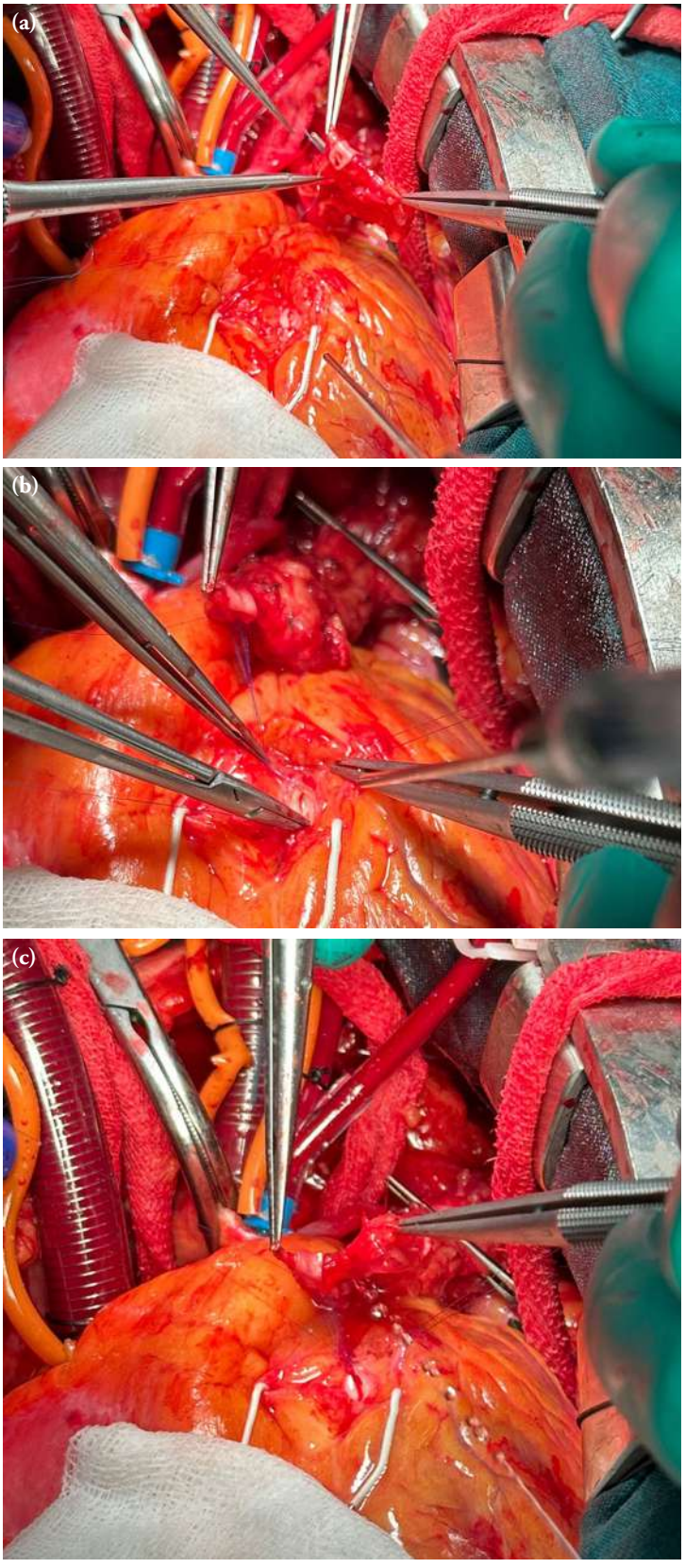


Photo 4.2. **(a,b,c)** After passing 4-5 sutures between the left internal thoracic artery (LITA) and left anterior descending artery (LAD), the loops in the threads are carefully taken, and the graft is seated. During the seating stage, the threads should be moistened to prevent slipping.

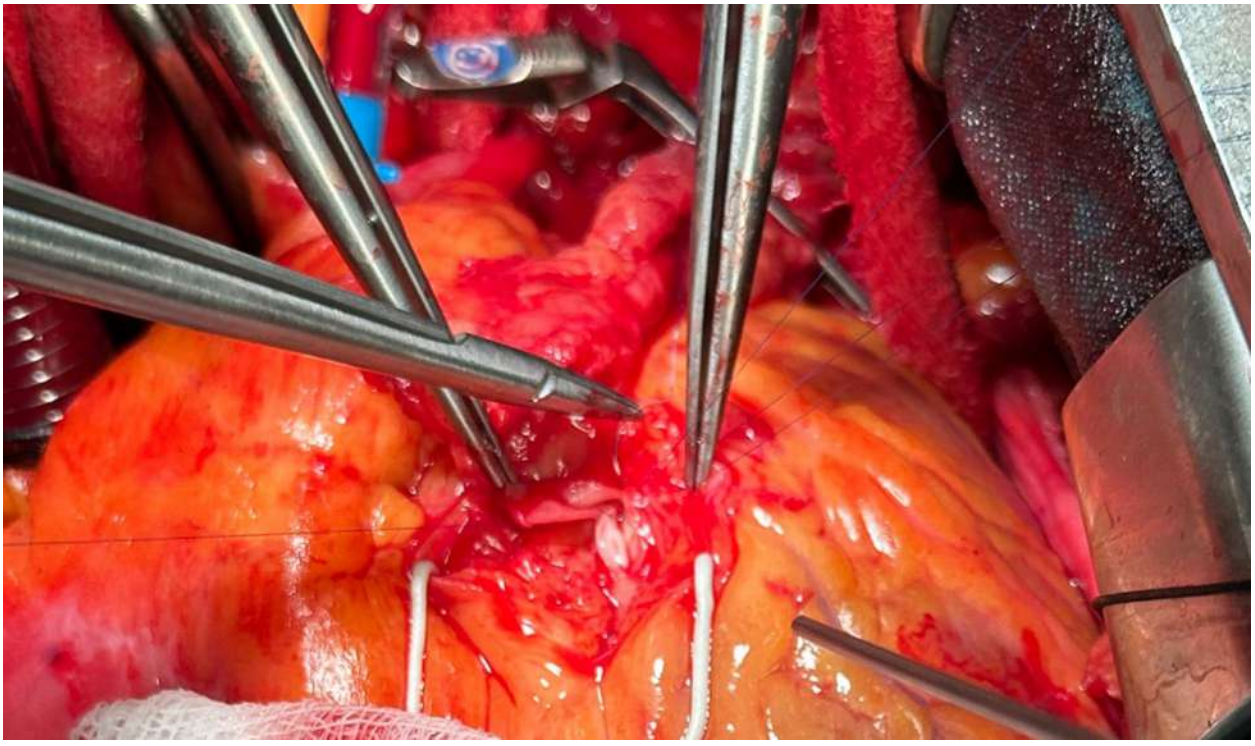


Photo 4.3. After seating the graft, suturing is continued.

may collapse inward, causing a "seagull-wing" deformity.

When the graft crosses the coronary artery, making the incision on the graft parallel to the long axis of the graft will yield beautiful results, forming a "diamond-shaped" anastomosis (Figure 4.5e and f). After making the cuts with the appropriate positions and angles, a side-to-side anastomosis is performed using the parachute technique. The anastomosis is made in a way that initially seats the heel, particularly when venous grafts are used, preventing potential bleeding due to incomplete seating of the sutures with the help of a hook.

The Interrupted Suture Technique

In this technique, 12 to 14 individual 7/0 polypropylene sutures are used to perform anastomosis between the graft and the coronary artery using the interrupted suture technique. This method can be particularly useful while anastomosing to small-diameter coronary arteries and is beneficial for cardiovascular surgeons early in their careers. Some surgeons, following the Cleveland Clinic style, prefer this technique routinely for all anastomoses. Initially, three individual sutures are placed and tied at the region forming the heel of the anastomosis (Figure 4.6a). Subsequently, 3 to 4 individual sutures are placed and tied on the wall opposite to the surgeon (Figure 4.6b). Three individual sutures are placed at the region forming the nose of the anastomosis (Figure 4.6c). Finally, 3 to 4 sutures are placed on the region of the anastomosis wall closer to the surgeon (Figure 4.6d). Previous studies have shown satisfactory patency rates with anastomoses created using this method (6). In contemporary practice, the nitinol U-clip® (Medtronic Inc., MN, USA) anastomosis device has become routine in some clinics, facilitating the interrupted suture technique.

Regardless of the method used, careful inspection for bleeding from the anastomosis should be conducted after its completion. While routine practice of every surgeon may differ, the distal anastomoses should be reviewed at three key stages: 1. immediately after anastomosis, 2. before removing the X-clamp, and 3. before coming off CPB. If no surgical bleeding focus is identified during these checks, the possibility that bleeding may cease after

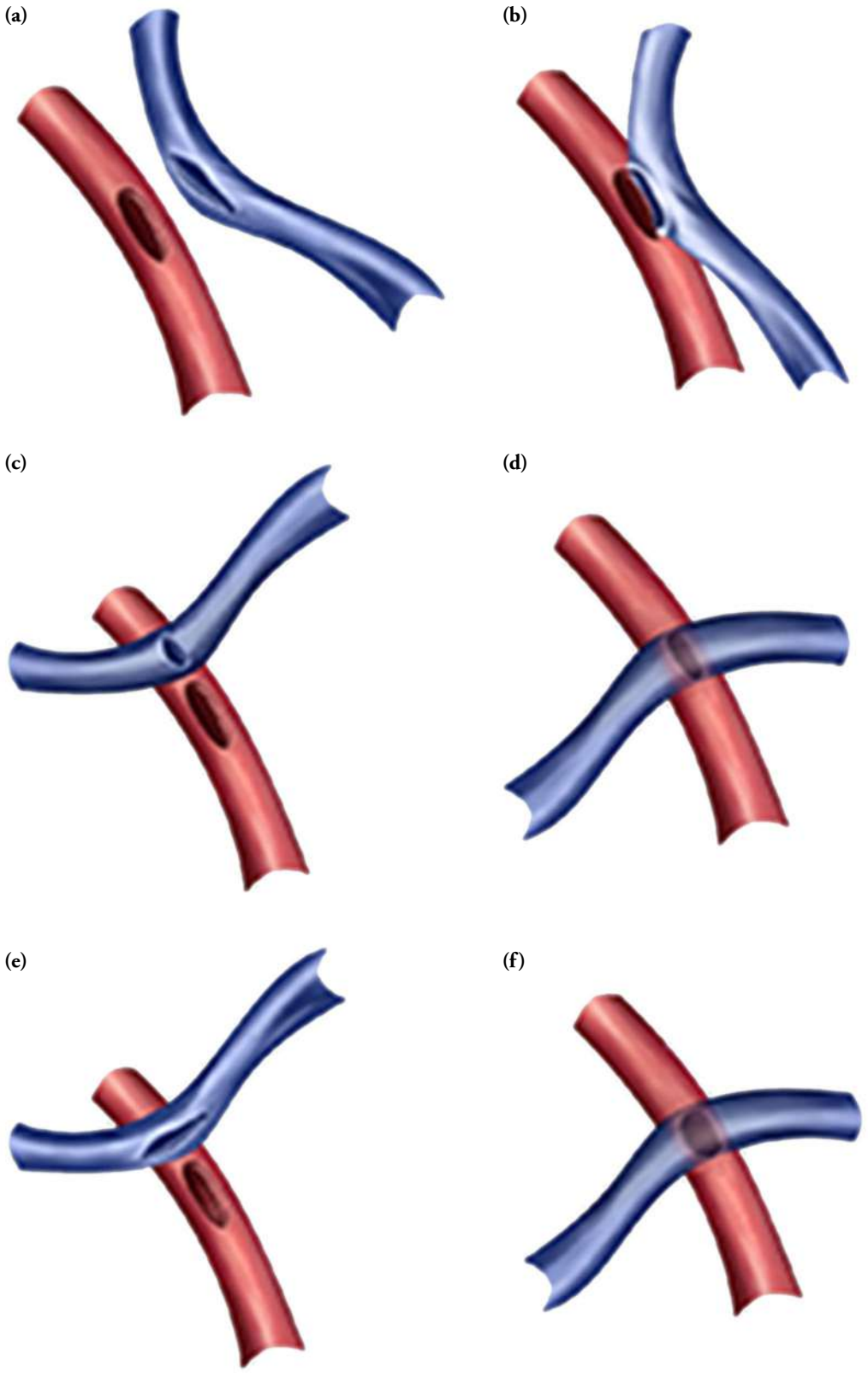


Figure 4.5. Side-to-side anastomosis technique. (The figure sequence is from left to right, top to bottom).

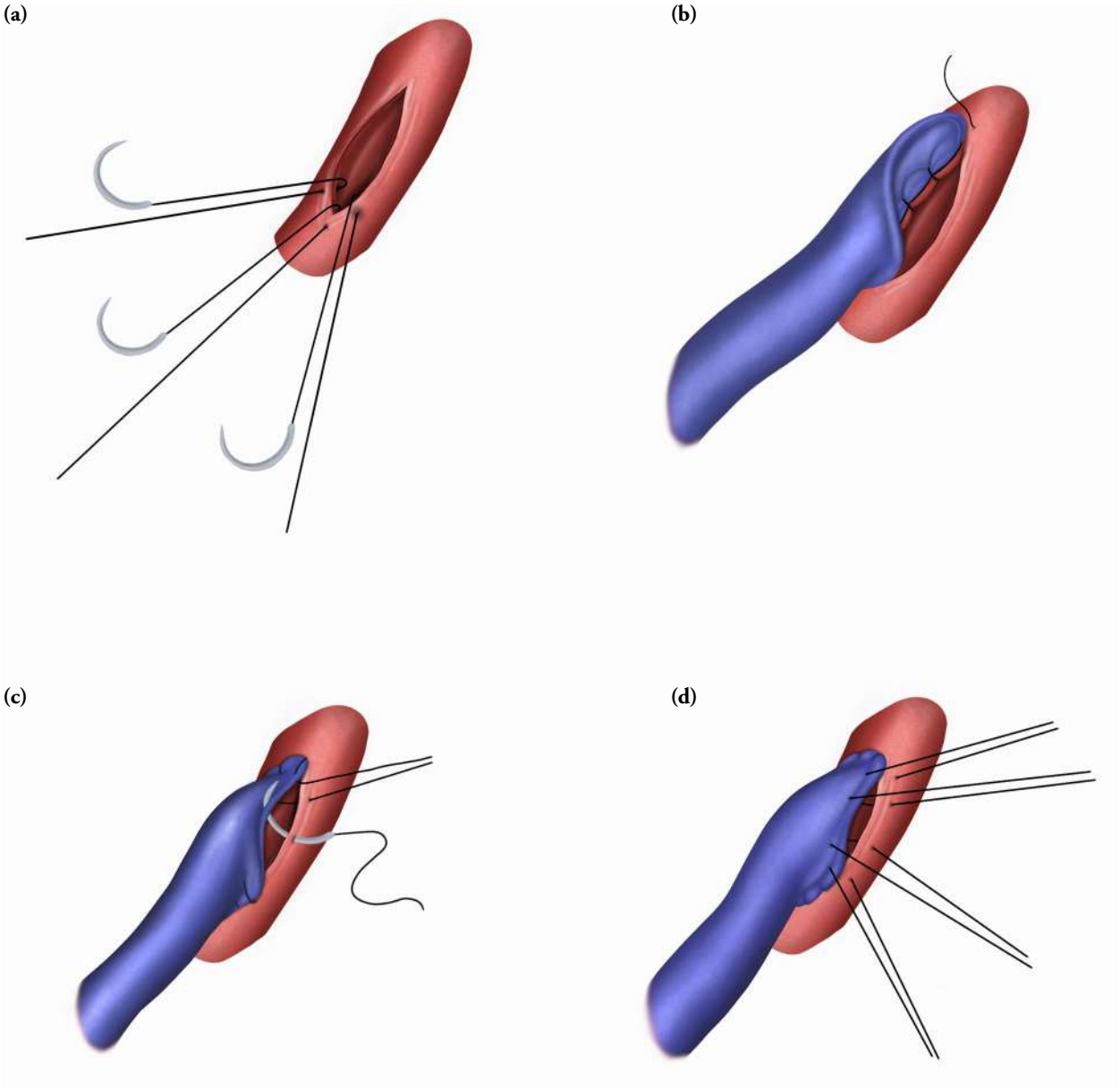


Figure 4.6. Anastomosis using the interrupted suture technique (The figure sequence is from left to right, top to bottom).

protamine administration, considering that the patient is still heparinized, should be kept in mind.

TROUBLESHOOTING

- Bleeding from the distal anastomosis site! First, check the following:
  - ✦ May there be a branch on the graft near the anastomosis?
  - ✦ May the sutures be loose?
  - ✦ Are the stitches unevenly placed, causing a "dog ear" formation in the anastomosis?
  - ✦ May the stitches have cut through, causing a tear in the graft or coronary?
  - ✦ May bleeding be coming from the cut epicardial fat or myocardium explored to access the coronary artery?