PREPARING THE LITA GRAFT

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LEFT INTERNAL THORACIC ARTERY (LITA)

Anatomy

Before proceeding to the preparation of the internal thoracic artery (ITA), it is crucial to understand the anatomy of this valuable graft. The ITA arises just behind the part where the clavicle attaches to the sternum, originating from the first part of the subclavian artery. As it descends caudally, it passes behind the brachiocephalic vein (Figure 1.1). At this point, it is also located behind the internal thoracic vein. The phrenic nerve is a significant neighboring structure at the exit of the ITA. It usually crosses obliquely in front of the ITA. Another important adjacency is the ductus thoracicus, a major lymphatic pathway. The terminal part of the ductus thoracicus ascends behind the brachiocephalic vein, curves slightly laterally (toward the shoulder), loops behind the internal jugular vein, and finally drains into the subclavian vein. The part of interest for us is where it ascends behind the brachiocephalic vein. In this area, there is a critical proximity to the ITA.

The neighbors proximal to the ITA are known to pose complications during graft preparation. Even gaining a few millimeters in this area holds importance while preparing a long graft. Particularly, as the surgical experience increases, more time is spent on the proximal ITA while preparing a long graft. Without a thorough understanding of the anatomy, complications such as diaphragmatic eventration due to phrenic nerve damage or chylothorax due to ductus thoracicus damage may occur. Moreover, severe bleeding can occur, particularly due to damage to the brachiocephalic vein, and may be challenging to control due to the anatomical location.

TIPS & PITFALLS

- Three critical adjacencies to be aware of at ITA proximal:
  - Phrenic nerve
  - Ductus thoracicus
  - Brachiocephalic vein
- Potential complications during ITA proximal dissection:
  - Diaphragmatic eventration and associated respiratory complications
  - Chylothorax
  - Severe venous bleeding.

After exiting from the proximal cut of the ITA, it descends approximately 1 cm lateral to the edge of the sternum. During this course, in the initial segments, it separates from the pleura with a thinner barrier. As it descends, around the second to third costal cartilage levels, the endothoracic fascia and transversus thoracic muscles become more prominent. Upon entering the thoracic cavity, during the initial exploration, the proximal segments can be directly visible, whereas the middle and distal segments may only be detectable through palpation at times. On both sides of the ITA, there are accompanying veins (venae comitantes). These veins converge at the third costal cartilage level, taking the name internal thoracic vein, and course medially to the ITA, draining into the brachiocephalic vein.

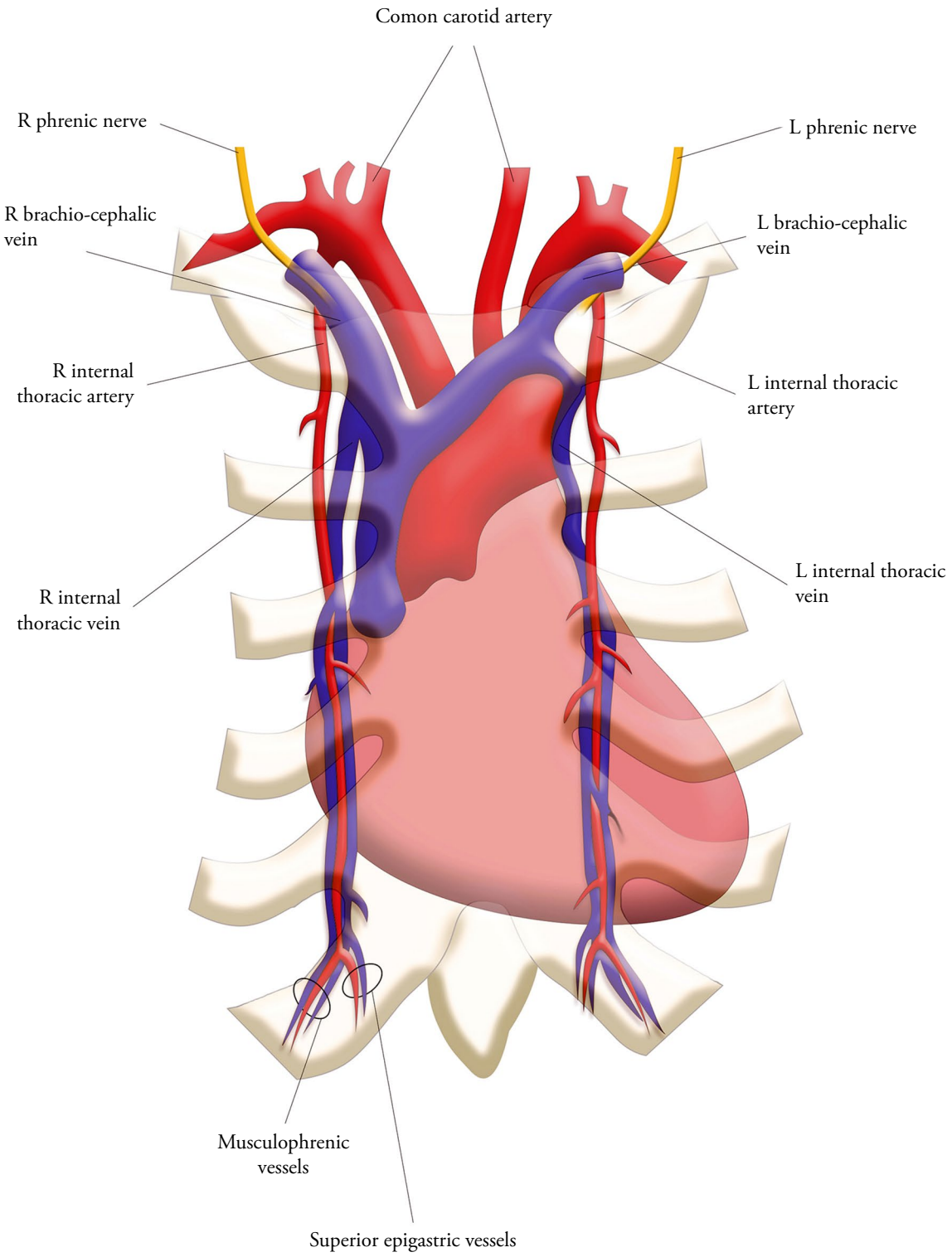

Figure 1.1. The ITA originates just behind the point where it attaches to the sternum from the clavicle, emerges from the first part of the subclavian artery, and descends caudally behind the brachiocephalic vein.

The branches of the ITA are a popular question in exams. The pericardiophrenic artery is the first branch of the ITA. It originates from the proximal part and courses medially, running closely with the phrenic nerve. During the mobilization of the ITA, it is located within the tissues holding the proximal to medial part of the pedicle. After this segment, the ITA gives numerous branches as it descends. Although often referred to as intercostal branches, they are named perforating, sternal, and intercostal branches, each with different courses.

The sternal branches direct medially to nourish the sternum. Perforating branches, on the other hand, ascend at a right angle, penetrating the intercostal muscles and advancing toward the pectoral area and breast tissue. Intercostal branches progress laterally, connecting with the posterior intercostals. Among the intercostal branches, the first intercostal artery holds particular importance. It is somewhat more developed than the others and, if not clipped during harvesting, it can divert a portion of the blood flow passing through the ITA.

Considering the courses of perforating, sternal and intercostal branches can be sensible during harvesting to prevent potential ITA-side branch separation injuries. Indeed, a significant portion of the damage which occurs during ITA extraction is attributed to insufficient precision and trauma to the perforating branches. After giving rise to these branches, the ITA bifurcates into two terminal branches at the level of the sixth intercostal space, concluding as the musculophrenic artery and superior epigastric artery.

TIPS & PITFALLS

- Branches of ITA:
  - Pericardiophrenic artery
  - Intercostal arteries
  - Perforating branches
  - Sternal branches
  - Musculophrenic artery
  - Superior epigastric artery.

HARVESTING

It is of utmost importance for the sternotomy to be performed along the median line for ITA harvesting. Using paramedian incisions, being too close or too far from the ITA can lead to difficulties in preparing the graft. The ITA may sometimes course farther away from the free edge of the sternum; in such cases, if a paramedian incision is made too far to safely extract the ITA in an anatomically structured patient, it may jeopardize the healthy retrieval of the graft. If the incision is made too close, there may not be enough space for the legs of the retractor to grip, or the retractor may not open as much due to insufficient sternal bone tissue, causing difficulties in visualizing the surgical field.

After a proper sternotomy, the used ITA retractor is placed. Gradually opening the sternum and reducing stress on the costochondral junction helps to avoid potential sources of significant postoperative pain. During sternal opening, pleural tissues are first released. There are two methods: the first involves directly opening the pleura to enter the thoracic cavity, and the second involves separating pleural tissues from the thoracic wall to expose only the ITA without opening the pleura. The first method is the standard approach and provides a good view, while the second method requires finding an appropriate dissection plan and may have positive effects on pulmonary functions postoperatively, avoiding complications such as pleural adhesions and reactive pleuritis. In some cases, the pleura can be opened unintentionally despite the efforts to avoid extrapleural removal.

After placing the retractor and opening the pleura, the proximal part of the ITA becomes visible. Gentle palpation allows understanding the course and pulse fullness of the ITA. The subsequent steps depend on whether the prepared ITA graft will be pedicled or skeletonized. Skeletonized grafts can have a longer length, with up to a 7 cm difference, which can be advantageous for multiple arterial grafting. This length difference is known to have positive effects on sternal blood flow and potential sternal dehiscence complications. On the other hand, during the preparation of pedicled grafts, it is easier to protect the ITA from possible mechanical and thermal trauma, and there are publications suggesting that the pedicle reduces spasm in the ITA.

TIPS & PITFALLS

- Pedicled ITA graft:
  - More protected against possible thermal and mechanical damage during harvesting

- ✦ Higher resistance to spasm in the early stages due to the preservation of the ITA wall's vasa vasorum and lymphatics
- ✦ Has a greater impact on sternal blood flow
- ✦ Easier extraction technique; electrocautery can be used.

- Skeletonized ITA graft:
  - ✦ Provides a longer graft
  - ✦ Facilitates multiple arterial grafting
  - ✦ Easier bleeding control, since there is no tissue hiding side branches
  - ✦ Suitable for removal with ultrasonic dissectors
  - ✦ Requires more experience
  - ✦ Particularly advantageous for bilateral ITA use in patients with diabetes regarding sternal dehiscence.

While preparing the pedicled graft of the ITA, the general outline of a 1 cm-wide pedicle is revealed by making two parallel incisions through the endothoracic fascia along the course of the ITA (Figure 1.2). Subsequently, dissection can be initiated either from the branching point at the distal end of the ITA or from the proximal end, typically at the third costal level, where it is most superficial and prominent. Once the fascia is partially released, tributary veins close to the operator, arteries, and other tributary veins and branches become visible. The tributary veins and branches are held with forceps, and appropriate cleavage over the artery is achieved using electrocautery or the blade of an ultrasonic dissector. If dissection started distally, it continues proximally or *vice versa*. Meanwhile, the endothoracic fascia is pulled down and slightly medial with forceps to reveal the ITA side branches (Figure 1.3). Larger branches are closed using hemoclips. After hemoclipping, the branches are cut using electrocautery or an ultrasonic cutter (Photo 1.1). Avoiding contact with clips during the cutting process is crucial to prevent thermal damage to the ITA. Applying excessive force during fascia retraction and identification of side branches with cautery/ultrasonic blade can lead to mechanical damage, manifesting as bleeding or mural hematoma on the ITA. This hematoma can cause disruption to ITA dissection, rendering the graft unusable. While mild thermal damage may

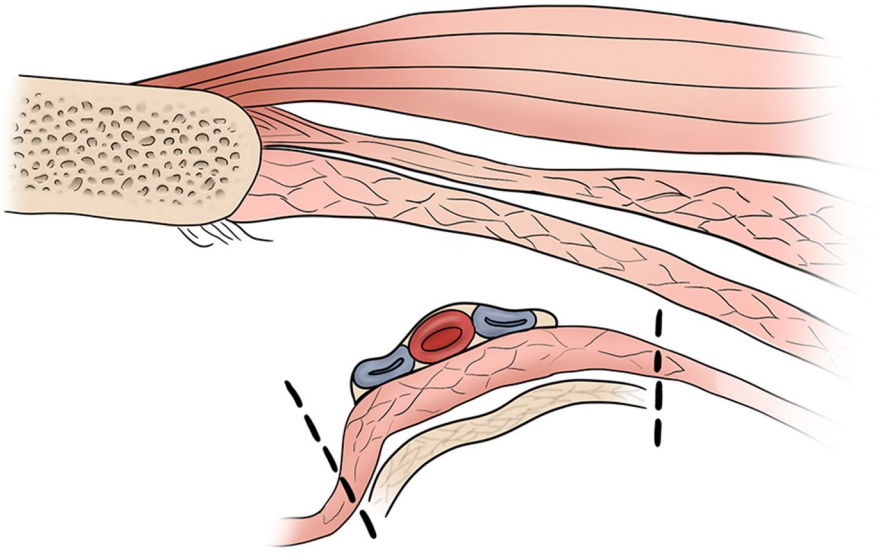

Figure 1.2. In this horizontal section, the left internal thoracic artery (LITA), accompanying veins, and fascia are visible within the chest cavity. The boundaries of the pedicle are determined by cutting the areas marked with dots. During this process, care should be taken not to get too close to the LITA or leave too much tissue. A pedicle of approximately 1.5 cm in width can be targeted.

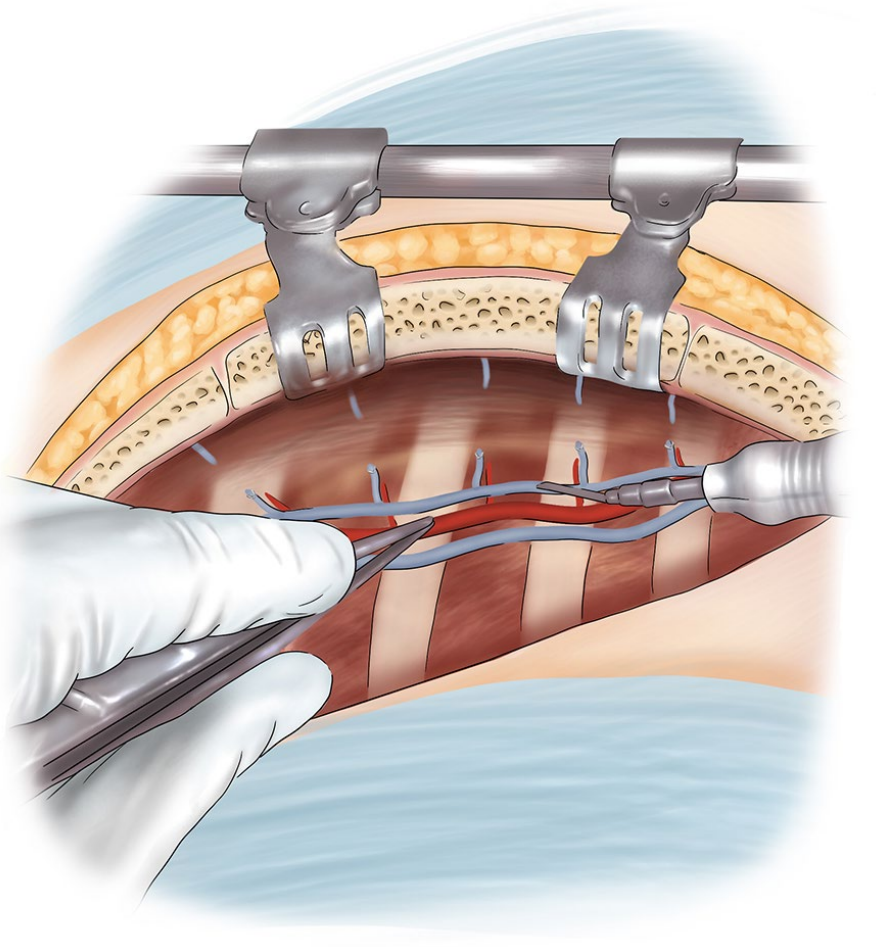

Figure 1.3. After placing the retractor and gradually opening it, the side branches of the left internal thoracic artery (LITA) and accompanying veins are clipped and separated. In this way, the boundaries of the pedicle begin to form. In the illustration, the fascia and tissues around the LITA are removed.

not cause immediate issues with blood flow, it can lead to strictures in the long term, depriving the patient of the ITA graft. Another common cause of thermal damage is allowing the blade to contact the ITA before cooling down after electrocautery dissection. Such issues are less common with ultrasonic dissectors. After separating the ITA side branches, dissection proceeds proximally, and often concludes while approaching major venous structures. Ensuring that the first intercostal is not ligated is important to avoid steal phenomenon in this region. Particular attention should be paid to the neighboring structures in this area, as mentioned in the previous section. Distally, the endpoint is where it bifurcates into musculophrenic and superior epigastric arteries. Preserving this bifurcation is known to have positive contributions to sternal vascularization.

If the ITA graft is considered to be insufficient in length after preparation, it can be extended by opening the endothoracic fascia and surrounding tissues with a few transverse incisions (Figure 1.4). If further length is needed, the pedicled graft can be

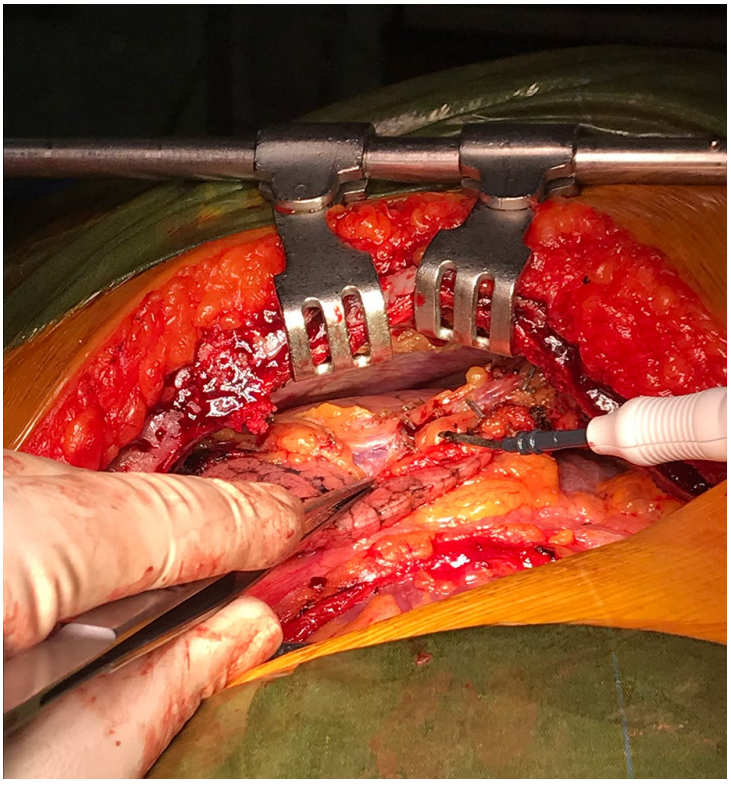

Photo 1.1. The forceps in the left hand grasp the pedicle of the left internal thoracic artery (LITA) from the fascial tissue, allowing the side branches to become more visible. Using electrocautery, the previously hemoclipped side branches are cauterized and separated. This helps to define the boundaries of the pedicled graft and to prevent bleeding from the side branches. Care should be taken to avoid excessive retraction and the electrocautery getting too close to the LITA at this stage.

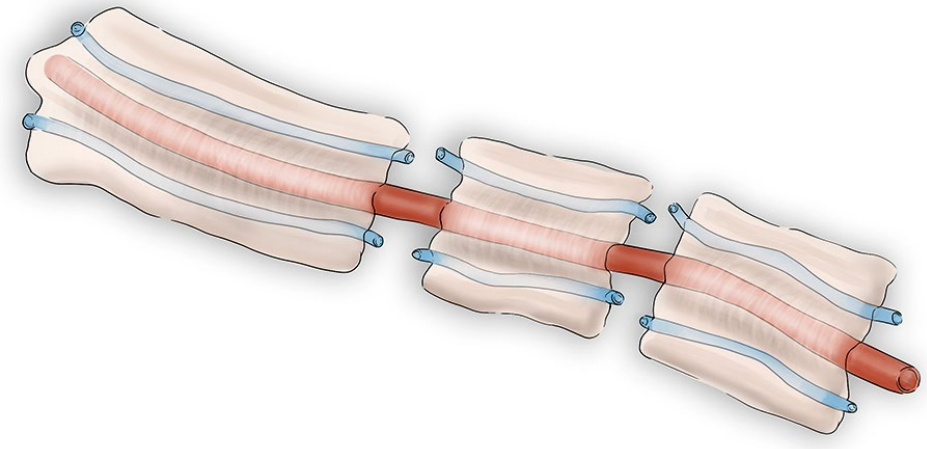

Figure 1.4. If the length of the graft, formed by separating it from the side branches to create a pedicle, is found to be short, the fascia constituting the pedicle can be horizontally cut at several levels to increase the length of the graft. Care should be taken at this stage to avoid damaging the LITA.

cut longitudinally to make it a skeletonized graft, but it should be noted that this method can lead to graft loss if not done with maximum care. After preparing a well-pedicled ITA graft with separated side branches using hemoclips and of sufficient length, systemic heparinization is performed (Photo 1.2). At this stage, there are two options for the graft. The first is the most applied method, which involves ligating and separating the distal end of the ITA before bifurcation. The blood flow of the ITA is visually assessed. If blood flow and pulsation are low, it is essential, particularly in short-necked and stout patients, to loosen the retractor slightly and check for control. However, if flow is still low, a visual hematoma in the graft, thermal damage, or a hemoclip placed too close to the ITA may be the cause. Regardless of the issue, any suspicion about the quality of the ITA graft should be clarified. Subsequently, either an open distal end is hemoclipped, or a bulldog vascular clamp is applied to occlude it. Clipping the distal end allows the ITA lumen to fill with heparinized blood and ensures arterial nourishment. It also prevents arterial spasms. The alternative method is for the distal end of the graft to continue *in situ* circulation, until it is separated for use. Regardless of the method chosen, wrapping the graft with a sponge soaked in papaverine prevents both mechanical trauma and spasms, until it is ready for use.

TROUBLESHOOTING

- Blood flow is not adequate in the ITA! First, seek answers to the following questions:
  - Is there a hematoma in the graft?
  - Have the hemoclips been placed too close to the arterial wall? Are there hemoclips on the ITA?
  - Is there flow in the proximal part of the graft? How far does pulsation continue, and where does it end?
  - Are there signs of thermal damage?
  - Is the graft of sufficient quality for use, considering the point where the flow was interrupted?

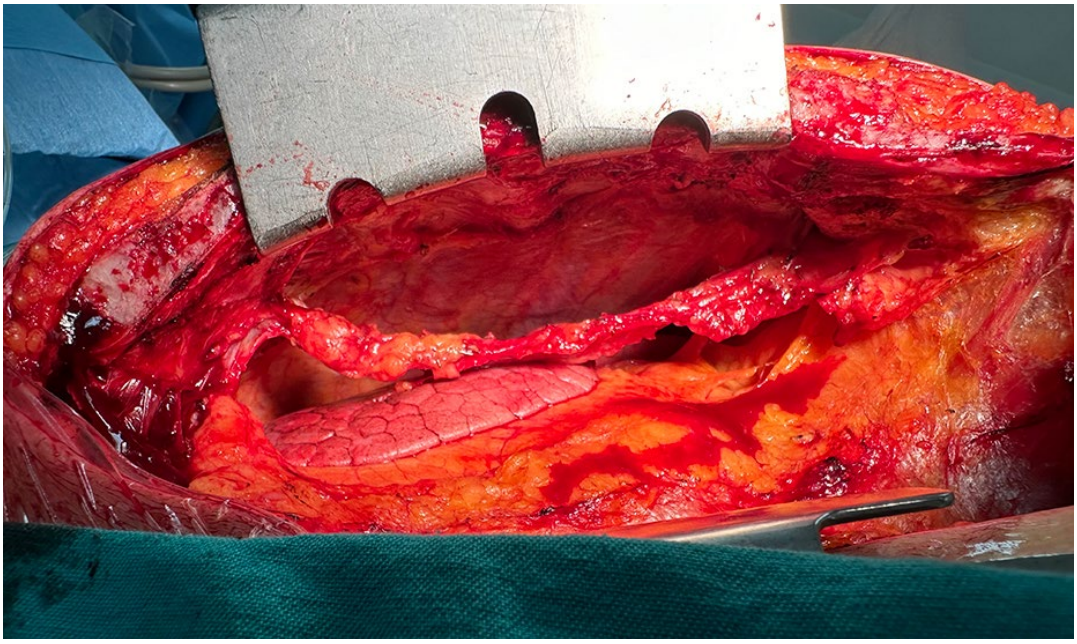

Photo 1.2. The pedicled graft, separated from the side branches, is seen *in situ*. It is seen that there are still side branches attaching the graft to the chest wall at the proximal part. Continuing the harvesting process toward the proximal cut will both extend the length of the graft and redirect blood flow to the LITA itself. The exposure may be slightly worse during the preparation of the proximal cut, and caution should be taken to avoid potential trauma to the graft.