31 Vascular Reconstruction in Oncologic Patients with Aortic and Visceral Artery Involvement

Domenico Palombo and Simone Mambrini

31.1 Introduction

Vascular surgeons play an important role in surgical oncology due to their familiarity with the preparation of vessels; their routine use of reconstructive techniques, be they vascular replacement or arterial and venous repair; their knowledge of surgical anatomy related to their experience with surgical access to the neck, chest, abdomen and limbs; and the knowledge they have of anaesthesiological and extracorporeal methods of circulation support.

While respecting oncology guidelines, it is conceivable that mixed surgical teams made up of vascular surgeons and general or thoracic surgeons could deal with locally advanced tumour lesions that would otherwise not be eligible for surgical treatment. Vascular surgery could, therefore, improve the outcomes of surgical oncology by increasing the radicality and safety of surgical procedures and in selected cases by broadening the range of surgical indications.

Clearly, both the patient's survival profile with regard to the neoplasm and the rationalization of resources must be respected. Therefore, once the oncology disease management team (DMT) has discussed and accepted the indications for surgery, high-volume surgical oncology centres could identify the surgically excisable tumours, and multispecialist teams, including vascular surgeons, would perform the surgery.

The role of the DMT in oncology is of paramount importance. It represents an opportunity for the oncologist and the surgeon to compare and discuss their specific surgical and oncological knowledge and experience with regard to a given case: the former must indicate what the most appropriate step is, while the latter must state whether surgery is indicated, i.e. whether surgery is feasible for the patient. In other words, the role of the oncology DMT consists in evaluating the best therapeutic strategy for the patient with respect to the tumour, its features and its developmental stage. The team must identify which patients should be sent directly to surgery, which should undergo alternative treatments (adjuvant or neoadjuvant radio-chemotherapy) prior to carrying out a safer surgical approach and which patients are still inoperable. This can be done thanks to our ever-increasing knowledge of oncology, as defined in terms of prognosis related to localization of the primary tumour lesion, its size and the presence and type of metastasis. It is also possible, thanks to the new perspectives provided by pharmacological and physical therapies (i.e. chemotherapy with new-generation drugs, radiation therapy with more powerful instruments), to obtain curative or palliative value. In particular, invasion of the vascular, arterial and/or

D. Palombo (✉) · S. Mambrini
Vascular and Endovascular Surgery Unit, University Hospital Policlinic San Martino of Genoa, University of Genoa, Genoa, Italy
e-mail: domenico.palombo@unige.it

Y. Tshomba et al. (eds.), *Visceral Vessels and Aortic Repair*,
https://doi.org/10.1007/978-3-319-94761-7_31

venous structures by the neoplasm is often considered a condition that excludes surgery. In fact, even tumours that are typically considered inoperable, such as pancreatic carcinoma with invasion of the mesenteric arterial axis or infiltrating lung neoplasms, can be eradicated by expert hands by combining the excision of the tumour mass, the necessary manoeuvres of cleavage from the vessels or resection and vascular reconstruction, often leading to surprisingly good results. Switching the various teams intraoperatively depends on the type of cancer being treated, the technical skills of the various surgeons and the teamwork that is created between them. Since the frequency of this type of surgery is rather limited (even in high-volume centres), to improve the degree of knowledge and mutual trust between the teams, as well as the technical skills and quality of work, it is important for a small number of vascular surgeon to be designated for this type of surgery.

For example, Fig. 31.1 shows the imaging of a typical case where a collegial discussion among the various specialists is needed to define the most appropriate therapeutic approach.

Although it is difficult to talk about rules in surgery, the experience gained in the field of surgical oncology over the years (averaging 12 interventions/year for locally advanced tumours involving the neck, chest, abdomen and limbs) has allowed us to reflect on what should or should not be done in this context.

Very few cases of arterial infiltration by neoplasms without coexistent venous involvement have been seen. Therefore, we must also consider the venous aspects of vascular treatment of locally advanced tumours. Moreover, extensive aortic infiltration continues to represent a contraindication to surgical oncology in most cases.

Our experience has led us to elaborate a number of general and specific standards or recommendations. Here we report the salient data of our experience.

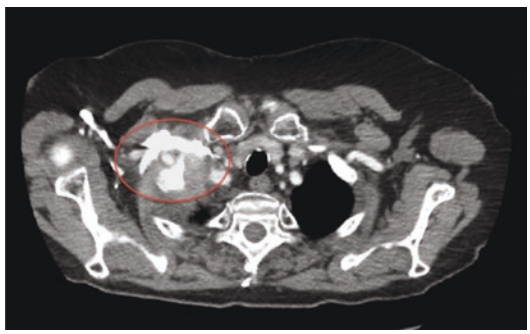

Fig. 31.1 A Pancoast tumour involving the right pulmonary apex and nearby vascular and neural structures

31.2 General Standards

It is important to plan the operative strategy and to share the surgical approach accurately, especially with regard to the need for vascular control upstream and downstream of the tumour mass. For example, Fig. 31.1 shows an angio-CT picture of a massive Pancoast tumour. It is evident that thoracotomy would not provide adequate vascular control given the presence of the first rib and clavicle and the apical site of the lesion. We prefer to approach similar cases using cervical-ministerno-thoracotomy and disconnecting the clavicle from the sternal manubrium in order to obtain adequate arterial and venous vascular control upstream and downstream of the lesion (brachiocephalic trunk, subclavian artery and its collaterals for the arterial part and the innominate, internal jugular and subclavian veins for the venous slope). Figure 31.2 shows the surgical preparation of a tumour mass infiltrating the superior vena cava which could force surgeons to broaden the surgical preparation given that such manoeuvers are time-consuming. This should be done prior to dealing with the tumour mass and certainly not only when intraoperative emergency situations occur, such as the rupture of a large vessel which makes every manoeuver more complex. In other words, whenever possible, calling the vascular surgeon must be avoided in emergency settings, such as during surgery following unexpected intraoperative findings which differ from preoperative imaging or, worse, that were underestimated a priori. For example, we were forced to perform surgery on the descending thoracic aorta through a right thoracotomy access. Thus, it is important to evaluate the option of a

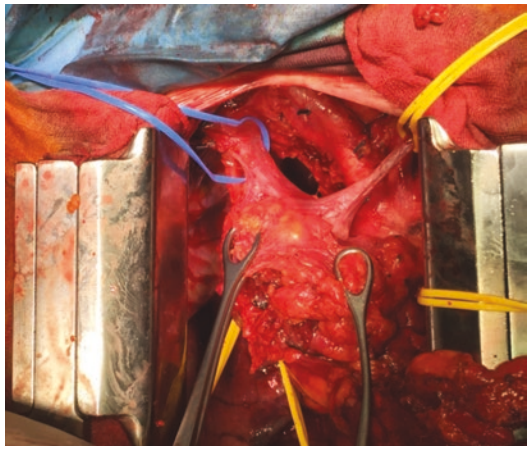

Fig. 31.2 Surgical preparation of a tumour mass infiltrating the superior vena cava; you can see that the innominate-caval system has been prepared above and below the tumour mass; two yellow silastic bands located below the mass surround the azygos vein (on the left) and the atrial outlet of the superior vena cava (on the right). In the background are the aortic arch and the supra-aortic vessels that have been cluttered by the tumour mass

vascular approach through other routes than the ones that are traditionally employed to treat the tumour lesion.

With regard to the type and site of the involved vessel, the possibility of saving the vessel, or the most reasonable reconstructive solutions, must be evaluated in advance, taking into account the high degree of invasiveness of cancer surgery in these cases. Figure 31.3 shows a case of sarcoma of the thigh in which the tumour mass is excised with complete vascular preservation.

It is imperative to preserve the integrity of the tumour mass in order to avoid coarse dissemination of neoplastic cells in the operative field which could be the cause of a local recurrence or distant metastases. This is the concept of "no-touch dissection".

Preserving the main vascular axis is a definite advantage in terms of both immediate and future outcome. The decision regarding the option of preservation or resection depends on the degree of adhesion of the tumour to the vessel and the presence of clear vascular infiltration. For example, Fig. 31.4 is a case of clear infiltration of the innominate-caval confluence and of the superior vena cava by a mediastinal tumour.

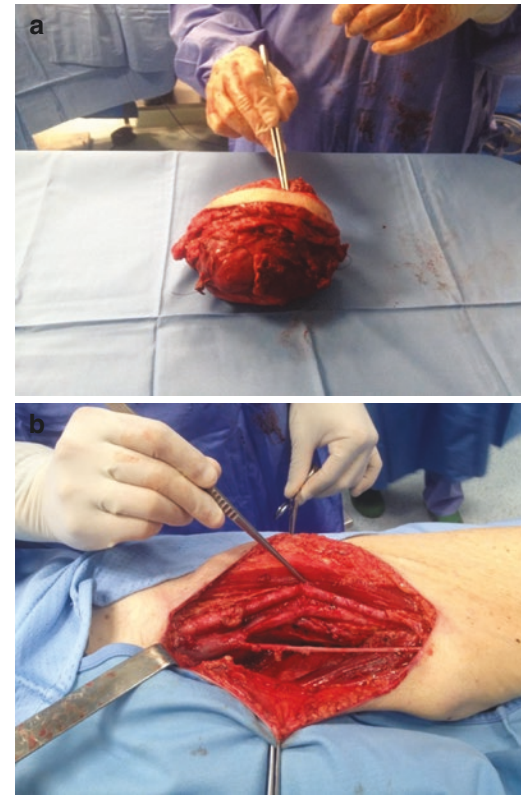

Fig. 31.3 Sarcoma of the thigh in which the tumour mass was removed with complete vascular arterial and venous preservation. (**a**) Tumour mass. (**b**) Intraoperative feature after sarcoma removal

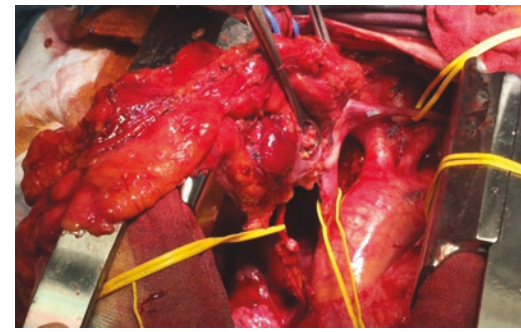

Fig. 31.4 Case of a clear infiltration of the innominate-caval confluence and of the superior vena cava by a mediastinal tumour. It should be noted that even the vagus and phrenic nerves are embedded in the cancerous mass

Once vascular control has been achieved upstream and downstream of the tumour, careful preparation of the vessels is required along their adventitial or sub-adventitial layer. The

manoeuver is carried out in both directions, from the centre towards the distal end and from the distal end towards the centre along the vascular axis with respect to the greatest adhesion portion between the vessels and the tumour. This must be done taking into account the possible presence of structures (e.g. the thoracic duct, the phrenic nerve, the vagus nerve in Pancoast lesions) which are increasingly incorporated in the tumour mass and thus require arterial and venous interruption.

When the tumour does not infiltrate the vessel, as is often observed in the presence of sarcomas, various branches of the main vessel enter into the cancerous mass. These branches should be interrupted to allow removal of the tumour without injuring the main vessel. It is preferable to interrupt the vascular branches by affixing sutures on the main vascular trunk (polypropylene 5/0 or 6/0, depending on their size) and clipping the branches on the side which penetrates the tumour mass.

Once the cleavage of the neoplastic lesion along the vessel makes the media easily recognizable in the arteries by the change in colour and consistency of the vessel, there are two options, (a) dissection and (b) "en bloc" resection. In the former case, the vascular wall must be reinforced by the use of banding techniques in order to prevent secondary fractures or pseudoaneurysm. In the latter case, reconstruction by termino-terminal grafts is necessary. An example is shown in Fig. 31.5.

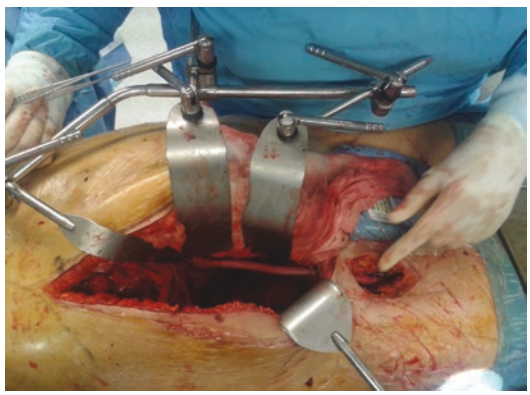

Fig. 31.5 Iliofemoral saphenous bypass graft after wide excision of endo- and retro-peritoneal metastatic carcinoma

31.3 Specific Standards

31.3.1 Large Vessel Involvement

In the presence of large vessel involvement (the aorta or abdominal veins), a rapid infusion system (RIS) is mandatory, while if lesions of the superior vena cava with atrial infiltration or an involvement of the suprahepatic segment of the inferior vena cava are suspected, it is appropriate to plan the use of extracorporeal circulation (ECC).

When the need for resection of the large vessels is expected, it is also important to have a suitable graft for reconstruction, including tubular segments of reinforced large calibre ePTFE (from 14 mm to 20 mm) or thoracic arterial homografts for the venae cavae, Dacron or Dacron Silver for arterial reconstruction and suitable saphenous segments or superficial autologous femoral veins (the validity of which will obviously have been studied preoperatively). For example, Fig. 31.6 shows a reconstruction of the superior vena cava carried out by the interposition of a tubular

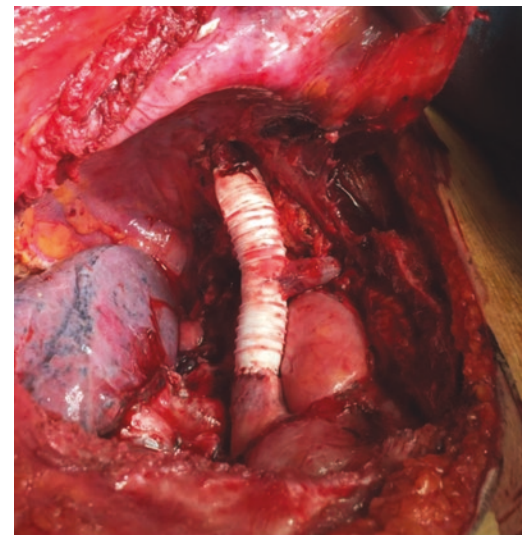

Fig. 31.6 Reconstruction of the superior vena cava carried out by interposition of a tubular ring-reinforced ePTFE (14 mm), placed between the right innominate vein and the inferior portion of the superior vena cava to which the left innominate vein was attached. Note the sterno-thoracic access with disengagement of the first rib from the sternum bar

ring-reinforced ePTFE placed between the right innominate vein and the inferior portion of the native vena cava to which the left innominate vein was attached.

31.3.2 Involvement of the Aorta

In the presence of aortic lesions (arch, thoracic or abdominal aorta), reconstruction significantly affects the outcome for obvious reasons. In these cases, our experience suggests the use of the most conservative techniques possible such as banding the aorta with Teflon or, better yet, with an autologous pericardial patch or, in the presence of accidental iatrogenic lesions, by directly suturing the aorta using Teflon pledgets. An example of an autologous pericardial patch for aortic banding is depicted in Fig. 31.7. All the aortic reconstructions by tubular substitution that we have carried out involve cases where the intraoperative picture was different from what was assumed by preoperative imaging or due to iatrogenic lesions that could not be repaired using a different conservative technique. In fact, we believe that lesions that extensively infiltrate the thoracic or abdominal aorta, in which oncological radicality depends on resection with tubular reconstruction, are contraindications to surgery. Regardless of perioperative outcomes, the prognosis of these patients remains burdened by very high short-term mortality. Therefore, the prerequisite for dealing with surgery on cancerous lesions that touch or infiltrate the aorta is the possibility to cleave the tumour or to limit the excision to a cuneiform resection.

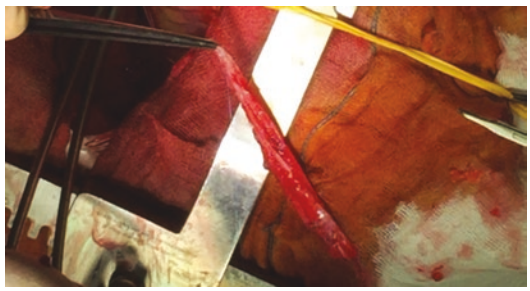

Fig. 31.7 Autologous pericardial patch for aortic banding

The access route depends on the aortic segment that is involved and on the nature and extent of the original neoplasm.

With regard to the ascending aorta and arch, the pathways we most frequently travelled included median sternotomy, sterno-cervicotomy and sterno-thoracotomy with possible detachment of the clavicle from the sternal manubrium.

One patient required descending thoracic aorta repair due to a recurrence of stromal carcinoma of the posterior mediastinum, which we carried out by right thoracotomy. The case in question is purely anecdotal and involved aortic clamping with retro-cardio-esophageal banding to reinforce the vessel. Unfortunately, traditional access to the thoracic aorta by left thoracotomy is not the most convenient way to excise tumour lesions of the posterior mediastinum, while it is optimal in the presence of aortic infiltration by tumours of the main bronchus or of the left lung.

31.3.3 Involvement of Large Veins

When the affected vessel is a vein, resection is more frequent because of the weaker structure of the vessel as compared to that of an artery. If in doubt, which is frequent when dealing with patients undergoing adjuvant radiotherapy due to the intense fibrotic reaction between the tumour and the vessel, the choice of the most appropriate dissection plane for cancer lesions may require an impromptu histological evaluation. The presence of neoplastic cellularity in the tested fragment often leads to resection. Figure 31.8 shows the dissection of an irradiated Pancoast tumour.

We limit vein reconstruction to the caval system and to the innominate trunk. In other cases, the solution may involve suturing the venous stump, possibly in the vicinity of side vessels or venous confluences in order to avoid a “cul-de-sac” effect, using an allez-retour polypropylene 4/0 or 5/0 on the vascular stumps. If a segmental resection of the vein wall can be performed, reconstruction with an autologous venous or pericardial patch sutured with polypropylene 5/0 or 6/0 or direct suture with the same procedures can be carried out. For example, in Fig. 31.9, a

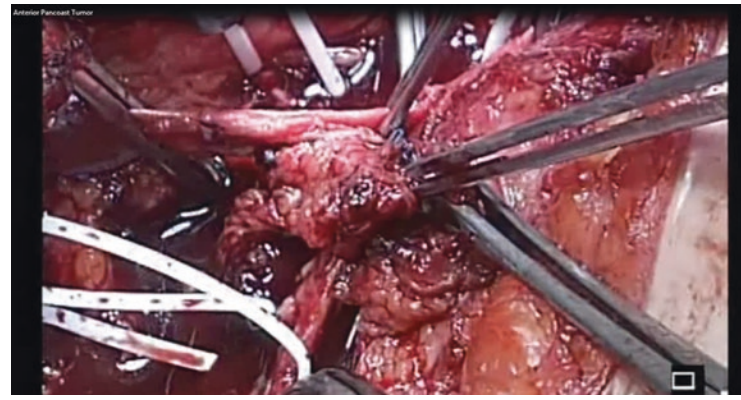

Fig. 31.8 Dissection of the irradiated Pancoast tumour

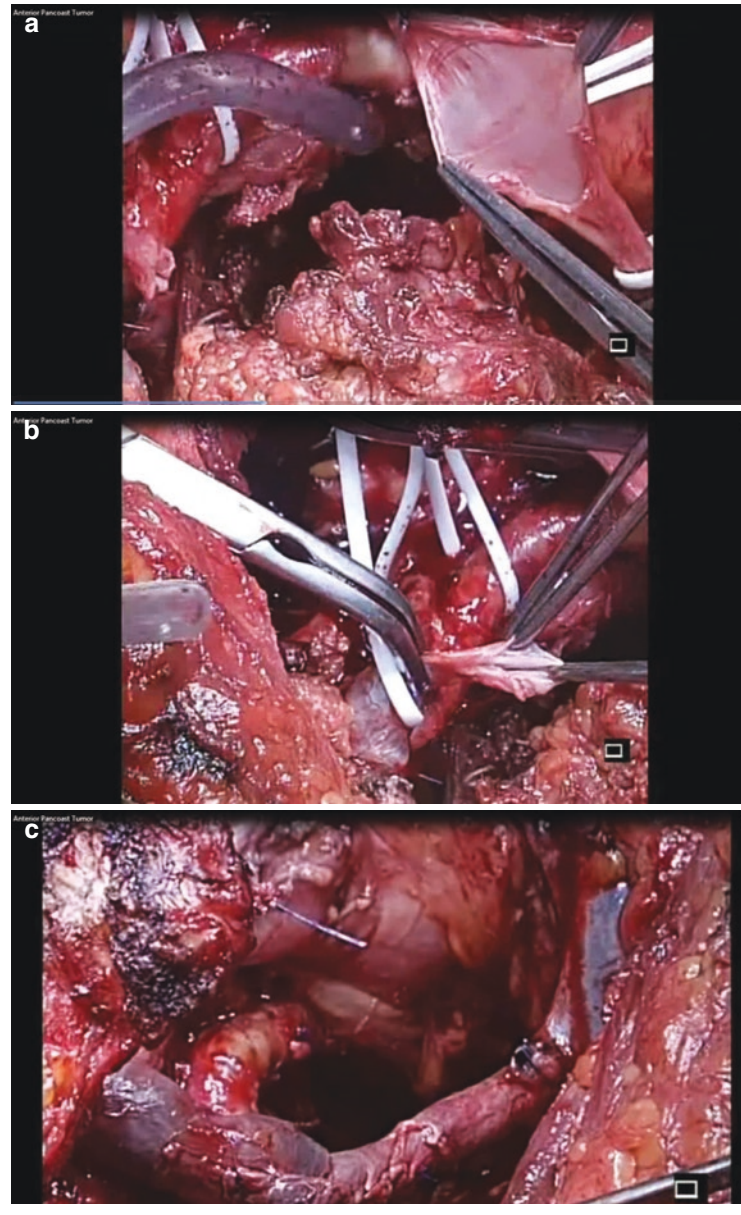

Fig. 31.9 Partial resection of the innominate vein and superior vena cava (**a** + **b**) with reconstruction and transposition (**c**)

partial resection of the innominate vein and superior vena cava reconstruction with transposition are shown, while Fig. 31.10 depicts a similar case in which we preferred reconstruction using an autologous pericardial patch.

Innominate or caval reconstruction may be done by end-to-end anastomosis of the venous stumps using polypropylene sutures 4/0 or 5/0 in the presence of limited resections or by using saphenous duplications, transpositions of the femoral vein and substitutes such as suitable calibre-reinforced ePTFE or homografts. In Fig. 31.11, a ringed ePTFE reconstruction of the left innominate vein is reported.

In the presence of neoplastic thrombosis of a venous trunk, and if it is not the cause of severe symptoms (such as mediastinal syndrome, Budd-Chiari syndrome or massive oedema of a limb), the fastest and most effective solution consists in resection without reconstruction of the venous trunk. On the contrary, cancerous lesions of the retro- or suprahepatic vena cava, secondary to the intraluminal extension of a renal adenocarcinoma or primary malignant disease of the vessel wall (angiosarcoma or leiomyosarcoma), warrant special treatment with regard to the preparation of surgical procedures and to the support that is sometimes needed for the circulation. In these cases, we emphasize the importance of careful haemodynamic monitoring using echo-transesophageal cardiography; the availability of RIS and ECC in the operating room is equally important. In these cases, full mobilization of the liver is imperative. This manoeuvre requires a rooftop incision or a Mercedes incision, preparation of the vascular pedicle, sectioning of all hepatic ligaments including the hepato-caval ligament, interruption of the Spigelian veins which should be clipped and sutured on both sides (vena cava and hepatic parenchyma), preparation of the suprahepatic veins (left, right and common trunk of the respective branches) and the preparation of the caval hiatus of the diaphragm which must be sectioned by the lateral-right phrenic approach

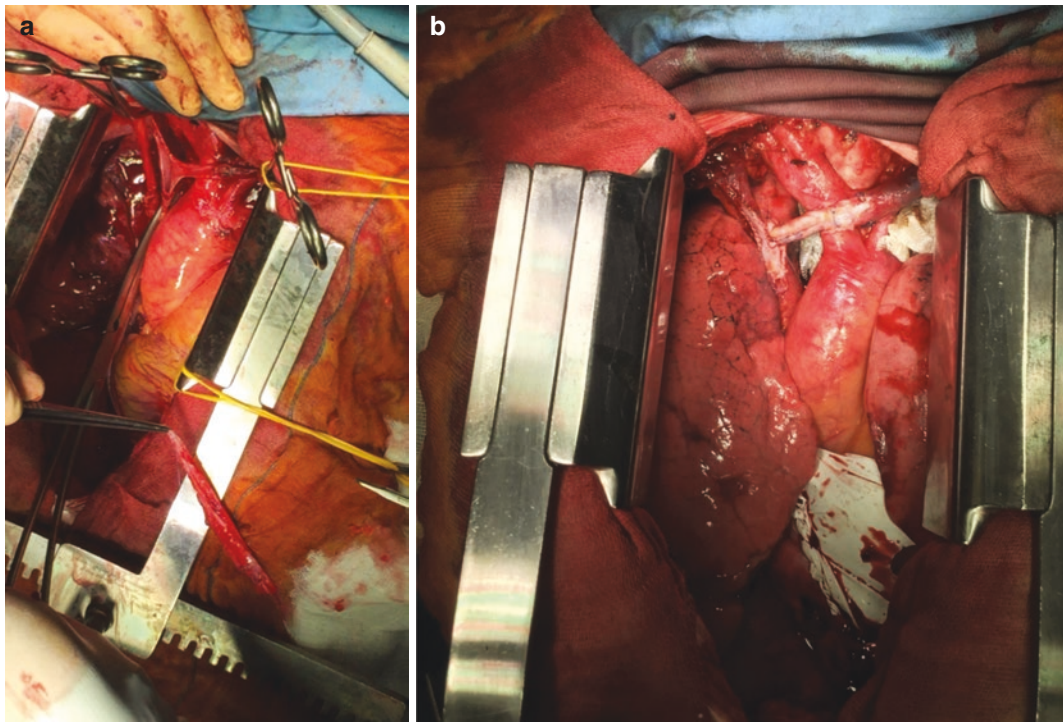

Fig. 31.10 Partial resection of the innominate vein and superior vena cava (**a**) with reconstruction using an autologous pericardial patch (**b**). In (**b**) note the presence of an ePTFE patch used to reconstruct the pericardium in order to avoid the twist of the heart in the perioperative

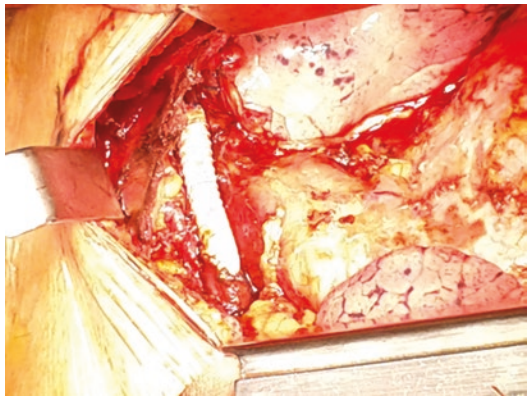

Fig. 31.11 Ringed ePTFE reconstruction of the left innominate vein after resection of a thymic carcinoma

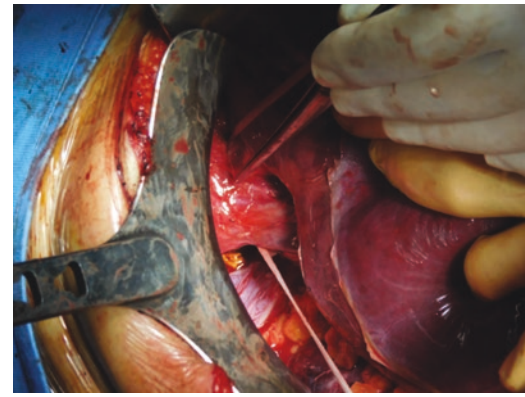

Fig. 31.12 Preparation of the suprahepatic segment of the inferior vena cava

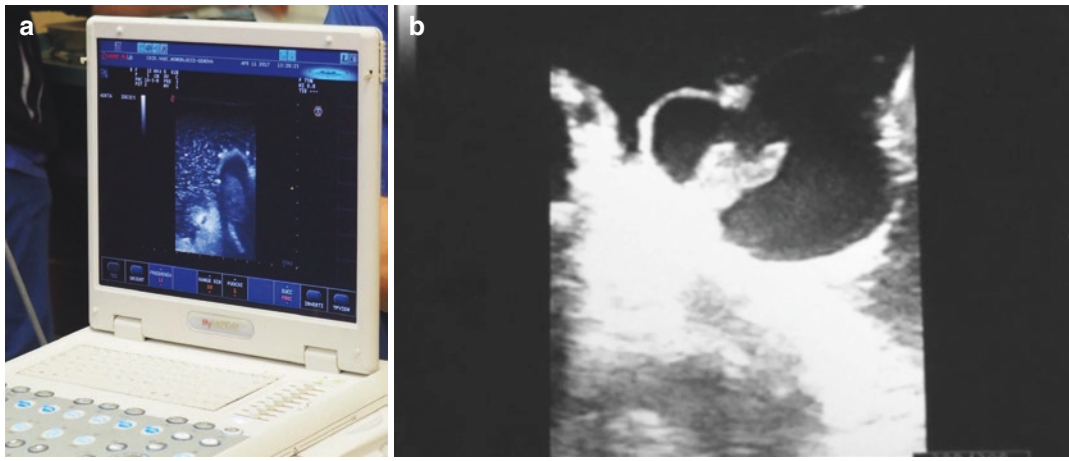

Fig. 31.13 Precise localization of the tumour along the vascular axis using intraoperative colour duplex scan (**a** + **b**)

in order to gain control of the intra-pericardial segment of the vessel. Figure 31.12 depicts the preparation of the suprahepatic segment of the lower vena cava.

If inferior vena cava cross-clamping is necessary, we prefer to test the caval cross-clamping tolerance before performing the cavotomy. In case of haemodynamic instability that cannot be anaesthesiologically controlled, it is imperative to guarantee adequate venous return to the right atrium by means of veno-venous splanchnic and somatic extracorporeal circulation (femoral vein + superior mesenteric vein to axillary vein) using a centrifugal pump. Furthermore, we prefer to perform an intraoperative colour duplex scan to evaluate the points of clamping which must be upstream and downstream to the longitudinal extension of the tumour, as shown in Fig. 31.13.

In cases of renal adenocarcinoma with invasion of the renal and inferior caval veins, the tumour does not adhere to the caval wall, except in the presence of superimposed paraneoplastic thrombosis. This results in very short infrarenal and above-the-liver (extra- or intra-pericardial) caval clamping time with contralateral renal vein clamping. The caval ostium of the renal vein that is attached to the neoplasm is used as the access site for the complete removal of the tumour. This is followed by caval side clamping, excluding the incision, and venous unclamping that restores physiological venous return. The surgical steps involved in these cases are described in Fig. 31.14.

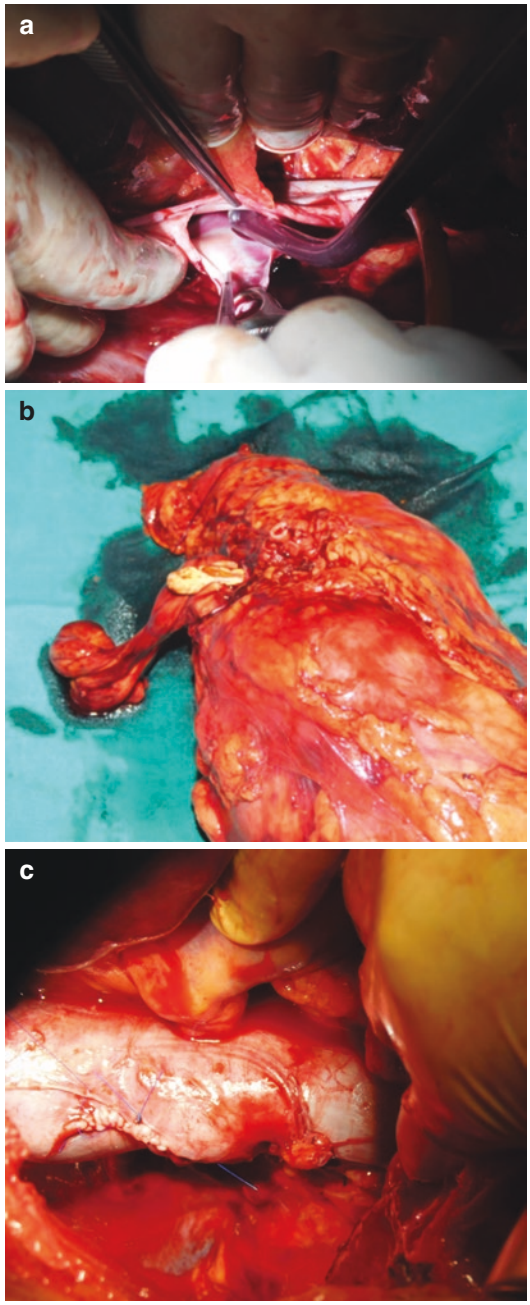

Fig. 31.14 Renal adenocarcinoma with invasion of the renal and inferior caval veins. (**a**) The caval ostium of the renal vein attached to the neoplasm is used as the access site for total removal of the tumour. (**b**) Surgical specimen coming from the kidney, deformed by adenocarcinoma and the neoplastic reno-caval thrombus. (**c**) Caval suture with the impression of the tangential clamping that was just made

The homografts we used were made up of descending thoracic aorta segments that had been cryopreserved and then grafted end to end between the caval stumps using polypropylene suture 3/0 or 4/0. The choice of the most suitable-sized homograft requires preoperative assessment of the patient's CT scan (on a workstation) in order to evaluate the minimum length and diameter of the segment to be replaced.

In cases of caval infiltration by adjacent neoplastic structures, such as lymph node packages or adrenal glands, segmental resection of the infiltrated portion of the cava is possible. During caval cross-clamping, we perform a longitudinal caval incision followed by a segmental trans-caval excision of the infiltrated portion of vessel and by a direct suture of caval margins of the resection; then, suture of the first cavotomy is performed during caval side clamping. The surgical steps involved in these cases are described in Fig. 31.15.

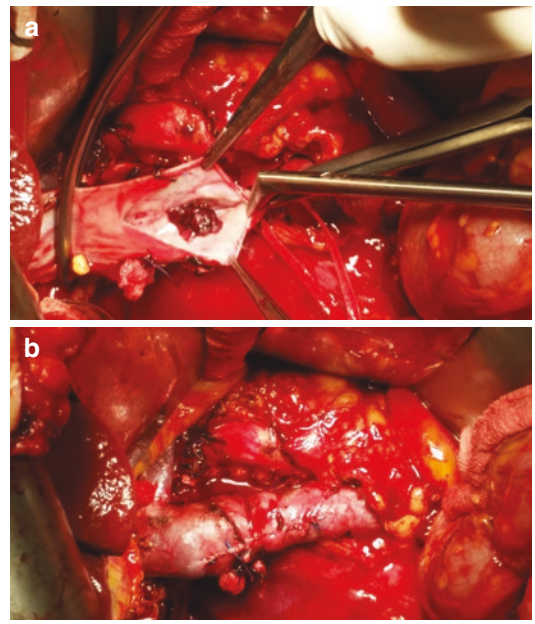

Fig. 31.15 Caval infiltration by adjacent neoplastic structures. (**a**) Segmental resection of the infiltrated portion of the cava using a trans-caval approach with direct longitudinal caval incision with total caval clamping. (**b**) Direct suture of the inferior vena cava after caval side clamping

31.3.4 Vascular Preparation to Myocutaneous Flap

In cases of wide resection of the chest or abdominal wall that has been infiltrated by cancer, it is important to evaluate the anatomic requirements for the possible reconstruction with a myocutaneous flap. Indeed, in the presence of extensive venous demolition, it is sometimes necessary to resort to autologous bridging to lengthen the vascular pedicles of the reconstruction flap.

31.4 Conclusions

The role of the vascular surgeon is of great importance in the treatment of locally advanced cancer cases.

A detailed collegial discussion of the individual case during oncological DMT meetings is equally important in order to accurately plan the surgery.

Cooperation among the various specialists is the only way to broaden indications and improve outcomes.

Despite the appealing possibility of dealing with injuries of almost any kind, oncological and surgical common sense is the main criterion when establishing indications to surgery.