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Successful venous repair and reconstruction for oncologic resections

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Objective: **We report our institutional experience of various venous reconstruction methods during oncologic resections, especially examining the patency of venous reconstructions and the conduits used.**

Methods: **All patients undergoing venous repair or reconstruction for oncologic resections between 2008 and 2014 were identified by a retrospective search of a prospectively maintained database at a single university hospital. Extent and manner of venous reconstruction and conduit or patch material were recorded. Need for intraoperative venovenous bypass or cardiopulmonary bypass was also recorded. Whereas no prescribed follow-up protocol has been instituted, patency and survival data as available were analyzed.**

Results: **During the study period, 127 patients were identified. Five patients had primary ligations, without limb loss. Of the remaining 122 patients, 77 (63%) underwent primary repairs, 23 (19%) had patch repair, and 22 (18%) had bypasses. Of these, 27 (22%) were for portal vein reconstruction during a Whipple procedure, 47 (39%) were for caval repair during caval thrombectomy in the setting of renal cell cancer, and 28 (23%) were for caval repair during resection for other abdominal malignant neoplasms. Venovenous bypass was used in 16 repairs and cardiopulmonary bypass in 10. The 1-year patency rates were 100% for primary and patch repairs and 86% for bypass graft reconstructions. Occlusions were suffered only in the prosthetic grafts group. There was no limb loss or significant long-term morbidity in patients with occluded grafts. Rate of infection was 0%, and there was no evidence of an increased infection rate in prosthetic or bioprosthetic conduits or patches. Perioperative mortality was 5.5%.**

Conclusions: **Overall, venous reconstruction for oncologic resection can be done safely with very low complication rates and low perioperative mortality. Prosthetic grafts can be used for most reconstructions with no infections and good patency rates. (J Vasc Surg: Venous and Lym Dis 2016;4:57-63.)**

A variety of malignant neoplasms, such as renal cell carcinoma (RCC), pancreatic cancer, and retroperitoneal and extremity sarcomas, have potential for venous invasion. En bloc resection and venous repair and reconstruction are often required to achieve good oncologic outcomes. Methods of reconstruction vary from primary repair to interposition grafts using autologous or prosthetic conduits.

Retroperitoneal tumors commonly originate from renal parenchyma or are sarcomas and can be manifested with inferior vena cava (IVC) involvement. RCC extends into the renal vein and IVC in 5% to 10% of patients.[1] Presence of tumor thrombus is not a contraindication to resection and is usually amenable to removal without major IVC reconstruction. On the contrary, retroperitoneal sarcomas often invade the wall of the IVC or in rare cases can arise from the cava itself. Intraoperative exposure and isolation of IVC depend on the extent of the tumor. The best method of IVC reconstruction after resection remains controversial. Several authors advocate primary ligations,[2,3] whereas others suggest reconstruction using autologous[4,5] or prosthetic conduits.[6,7]

Pancreatic adenocarcinoma is another malignant neoplasm that commonly is manifested with venous invasion. Portal vein (PV) or superior mesenteric vein invasion is not always a contraindication to resection.[8] Several methods of reconstruction have been described in the literature, including primary or patch repair and reconstruction with interposition graft. Grafts used in prior reports include femoral and saphenous vein,[9] spiral vein,[10] internal jugular vein,[8] left renal vein,[11] and prosthetic grafts.[12]

Malignant neoplasms of the extremities frequently are manifested with vascular involvement. The paradigm of management of these malignant neoplasms has shifted in recent years from primary amputation to successful limb salvage.[13-15] Venous resection with negative margins and successful reconstruction play an important role in these patients' survival, limb salvage, and preservation of function.

The objective of this study was to analyze a single-institution experience with various venous reconstruction methods during oncologic resections involving the IVC, PV, and upper and lower extremity veins. Our analysis examined the patency of venous reconstructions and the infectious risk of various conduits.

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METHODS

All patients undergoing venous repair or reconstruction for oncologic resections between 2008 and 2014 were identified by a retrospective search of a prospectively maintained database at a single tertiary academic medical center. Demographic characteristics, including age, gender, type of malignant disease, and vessels involved, and procedural characteristics, including extent and technique of venous reconstruction as well as type of conduit or patch material used, were collected. Need for intraoperative venovenous bypass or cardiopulmonary bypass (CPB) as well as perioperative mortality was also recorded. The majority of patients were observed by the oncology team, who routinely performed surveillance imaging, which was used to analyze patency and rate of graft infection. Survival data were analyzed on the basis of the Social Security database and hospital records.

Data collection and analysis were conducted in accordance with the University of Pennsylvania Institutional Review Board. The waiver of informed consent and Health Insurance Portability and Accountability Act waiver of authorization were approved by the Institutional Review Board committee.

Statistical analysis was performed with Stata software (*Stata Statistical Software: Release 13*; StataCorp LP, College Station, Tex).

Surgical techniques. Vena cava reconstruction. Incisions used in this series included midline laparotomy and thoracoabdominal and bilateral subcostal incisions and were selected on the basis of the extent of the tumor and the surgeon's preference. Median sternotomy was used when tumor extended into the heart. The location of proximal and distal control of the cava also depended on the extent of the tumor. The Neves and Zincke[16] classification was used to define extent of tumor invasion (Table I). For level I and level II tumors, vascular control was established by isolating the infrarenal and suprarenal IVC. For level III tumors, liver mobilization was performed to obtain suprahepatic control of the IVC. For all patients with level III tumors, venovenous bypass with an extracorporeal pump and circuit was established; 16F sheaths were percutaneously placed in the femoral veins for the inflow and right internal jugular vein for the outflow. For patients with level IV tumor extension, CPB was used in collaboration with cardiac surgery. All patients requiring venovenous bypass or CPB were heparinized. Other patients were heparinized selectively on the basis of the amount of preceding intraoperative bleeding. After vascular control was established, cavotomy and tumor extraction were performed for RCC (Fig 1), and IVC resection was performed for retroperitoneal sarcomas (Fig 2).

Table I. The Neves and Zincke classification

Level	*Extent of tumor extension*
I	Involvement of IVC at the renal vein and extending into the IVC <2 cm
II	Involvement of infrahepatic IVC >2 cm above the renal vein
III	Involvement of the retrohepatic IVC
IV	Involvement of the supradiaphragmatic IVC (extending into right atrium)

IVC, Inferior vena cava.

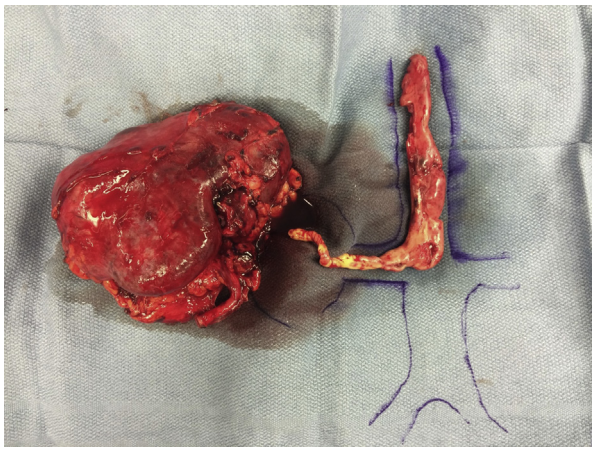

Fig 1. Nephrectomy and renal cell carcinoma (RCC) tumor thrombus.

The approach to reconstruction was dependent on the degree of caval involvement, which was determined on the basis of preoperative imaging, either contrast-enhanced computed tomography or magnetic resonance imaging. If <50% of the IVC circumference was involved, primary repair with running polypropylene sutures was performed (Fig 3). If the primary repair could not be accomplished without narrowing the IVC, patch repair with bovine pericardium was preferred (Fig 4). When circumferential replacement was necessary, 20-mm ringed polytetrafluoroethylene (PTFE) graft (Fig 5) or cryopreserved aortic homograft was used, depending on the degree of intraoperative contamination with gastrointestinal contents or urine.

PV reconstruction. PV reconstruction was performed in selected cases of pancreatic and biliary cancers. Primary repair was performed if the vein could be repaired without narrowing. In other cases, autologous vein or bovine pericardial patch was used to patch the PV (Fig 6). Autologous vein was preferred in cases of significant intraoperative contamination as long as the patient was hemodynamically stable and could tolerate an additional time required for a vein harvest. If a circumferential segment of the vein required replacement, autologous vein or cryopreserved homograft was used. For the autologous vein conduit, an internal jugular vein was preferred to a saphenous vein because of a better size match.

RESULTS

A total of 127 patients underwent venous repairs or reconstructions for oncologic resection during the study period. Patients' demographic characteristics, type of