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Surgery for vascular tumor invasion

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***Aim*. The aim of this paper was to evaluate our clinical experience and surgical results with oncologic procedures associated with major vascular resection and reconstruction on elective or emergent basis.**

***Methods*. A retrospective study was performed on patients who underwent major vascular resection for malignancy in our hospital between January 2000 and January 2011. Data collection was organized for patient demographics, intraoperative findings, and postoperative outcome.**

***Results*. Thirty-six patients were treated with 36 reconstructive procedures; 18 (50%) of them were major-vessel reconstruction, 11 (30.6%) of them were bypass procedures, and 7 (19.4%) of them were primary repair. Concomitant vascular interventions were performed electively as part of a planned oncologic procedure in 22 (61.1%) patients or emergently in 14 (38.8%) patients due to a vascular complication that occurred during tumor resection. Postoperative morbidity rate related to vascular intervention was 16.6% and mortality was observed in 2.8% of the patients due to pulmonary embolism.**

***Conclusion*. The results reported herein support that the need for resection and reconstruction of a major vascular structure should not prohibit the resection of any given tumor. The study demonstrates that most major vascular reconstructions have a high degree of success, and do not result major complications.**

KEY WORDS: Neoplasms - Neoplasms, surgery - Vascular diseases.

Adequate surgical clearance of neoplastic disease becomes problematic when the tumour mass encases a major vascular structure. This may be taken by some as an indicator of non-resectability.[1] Over the past few decades, in patients with malignancy, indication for resection of the tumors with invasion of major vascular structures that necessitate associated reconstruction have steadily widened.[2] This is particularly true in the management of carcinoma invading the carotid artery, the axial extremity vessels, the renal vein, and the vena cava.[3-6] Reconstruction of the involved portal vein during pancreaticoduodenectomy has also been used selectively with some success.[7]

Although some authors have reported that vascular reconstruction conjunction with resection of the tumor has favorable outcomes, some have demonstrated that the long-term survival rate was poor when resections for carcinoma are associated with major vessel infiltration or a complication that necessitates an emergent vascular intervention.[1-7] Fur-

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thermore, there is a paucity of reports that address vascular complications associated with major arterial or venous procedures performed during resection for carcinoma or for rescue of a complicated tumor resection.[1, 2]

The aim of this report is to evaluate our long term clinical experience and surgical results with oncologic procedures associated with major vascular resection and reconstruction on elective or emergent basis.

Materials and methods

This was a retrospective review at a tertiary referral center. The study was approved by the local ethics committee. Patients were treated for concomitant tumor resection and major vascular resection and reconstruction between January 2000 and January 2011. Data collection was organized for patient demographics, intraoperative findings, and postoperative outcome. Patient profile included age, sex, and comorbid conditions. Intraoperative findings included type of surgery (elective or emergent), invaded vessel, tumor localization, type of vascular reconstruction, and histopathologic findings. Postoperative outcome included assessment of graft patency, reinterventions, vascular and non-vascular complications and early mortality.

Surgical technique

All patients were operated under general anesthesia and endotracheal intubation. Before complete resection of tumor with involved tissues, affected vasculature was snared on proximal and distal part. Prior to vascular clamping patients received systemic heparin. Tumor resection, vascular resection and reconstruction were performed using standard operative techniques and appropriate vascular grafts.

Results

Thirty six patients (14 female and 22 male) who underwent major vascular resection for malignancy were identified between January 2000 and January 2011 in our clinic. Mean patient age at the time of treatment was 53 (range 18 to 68) years. Medical comorbid conditions included hypertension in seven (19.4%) patients, diabetes mellitus in two (5.6%) patients, chronic obstructive pulmonary disease in four (11.1%) patients, tobacco usage in 18 (50%), history of elevated cholesterol level in four (11.1%), coronary artery disease in two (5.6%) patients.

Preoperative characteristics of the patients, distribution of tumor localization, type of vascular involvement, procedures used to achieve vascular integrity, types of graft material, and operative complications were shown in Table I. The localization of the malignant tumor was abdominal in 13 (36.1%) patients, pelvic in 11 (30.6%) patients, extremity in two (5.5%) patients, thoracic in four (11.1%) patients, and neck in six (16.7%) patients. The distribution of tumor localization by organ site of the primary tumor was shown in Table II.

Concomitant vascular interventions were performed electively as a part of a planned oncologic procedure in 22 (61.1%) patients or emergently because of a vascular complication that occurred during tumor resection in 14 (38.9%) patients (Table I). These emergent vascular surgical interventions were for inferior vena cava in three patients, carotid artery in three, aorta in two, and iliac artery and vein in six patients. The distribution of invaded vessels by the primary tumor was shown in Table III. Vascular resection and reconstruction associated with tumor resection included infrarenal aortic resection and prosthetic graft interposition in six patients (16.7%), inferior vena cava resection and patchplasty in five patients (13.9%), vena cava inferior resection and graft interposition in three patients (8.3%), iliac artery and/or resection and reconstruction in 11 patients (30.6%), femoral artery and/or vein resection and reconstruction in two (5.6%) patients, subclavian artery and/or vein resection and prosthetic graft interposition in three (8.3%) patients and carotid artery reconstruction in six (13.9%) patients. The distribution of vascular interventions associated with tumor resection were shown in Table IV.

Postoperative morbidity related to vascular intervention was 16.6% and included revision for bleeding in two patients and thrombosis of iliac and femoral veins in two patients. Pulmonary complications were detected in two cases while renal failure, cerebral stroke and acute coronary syndrome were complicated one patient each. The operative mortality was 2.8% as one patient died on postoperative 27th day due to pulmonary embolism and multiple organ failure that followed emergent inferior vena

TABLE I.—*Patient demographics, intraoperative findings, and postoperative outcome of the study group.*

No.	Age	Gender	Tumor Localization	Invaded Vessel	Elective/ Emergent	Treatment	Graft Material	Tumor Histopathology	Complication
1	53	F	Kidney	Aorta	Elective	Primary repair	-	Clear cell adenocarcinoma	
2	58	M	Kidney	Aorta	Elective	Primary repair	-	Renal cell carcinoma	
3	23	M	Testis	Aorta	Elective	Reconstruction	Dacron®	Poorly differentiated germ cell tumor	Revision due to bleeding
4	32	M	Testis	Aorta	Emergent	Reconstruction	Dacron®	Seminoma	
5	30	M	Testis	Aorta	Elective	Reconstruction	Dacron®	Teratocarcinoma	
6	61	F	Esophagus	Aorta	Emergent	Primary repair	-	Squamous cell carcinoma	Pulmonary complications
7	68	F	Pancreas	Vena cava inferior	Elective	Reconstruction	Dacron®	Adenocarcinoma	Acute renal failure
8	46	M	Testis	Vena cava inferior	Emergent	Primary repair	-	Poorly differentiated germ cell tumor	
9	33	M	Testis	Vena cava inferior	Elective	Reconstruction	Dacron®	Poorly differentiated germ cell tumor	
10	60	F	Kidney	Vena cava inferior	Elective	Reconstruction - thrombectomy	PTFE	Renal cell carcinoma	
11	68	M	Kidney	Vena cava inferior	Emergent	Primary repair	-	Renal cell carcinoma	Pulmonary embolism -exitus
12	40	M	Testis	Vena cava inferior	Elective	Reconstruction	Dacron®	Teratocarcinoma	
13	59	F	Ovary	Vena cava inferior	Elective	Reconstruction	PTFE	Epithelial tumor	Revision due to bleeding
14	58	M	Testis	Vena cava inferior	Emergent	Primary repair	-	Choriocarcinoma	
15	57	F	Cervix	Iliac artery	Elective	Bypass	PTFE	Squamous cell carcinoma	
16	65	M	Rectum	Iliac artery	Emergent	Extra-anatomic bypass grafting	PTFE	Adenocarcinoma	
17	63	F	Ovary	Iliac artery	Elective	Bypass	PTFE	Epithelial tumor	
18	67	F	Cervix	Iliac artery	Emergent	Extra-anatomic bypass grafting	PTFE	Squamous cell carcinoma	
19	60	M	Bladder	Iliac artery	Elective	Bypass	PTFE	Transitional cell carcinoma	
20	63	M	Bladder	Iliac artery	Emergent	Bypass	PTFE	Transitional cell carcinoma	
21	32	M	Testis	Iliac artery	Elective	Reconstruction	PTFE	Poorly differentiated germ cell tumor	
22	18	M	Testis	Iliac artery and vein	Elective	Reconstruction	PTFE	Teratocarcinoma	
23	57	F	Cervix	Iliac artery and vein	Emergent	Reconstruction	PTFE	Squamous cell carcinoma	Iliac vein thrombosis
24	59	F	Cervix	Iliac artery and vein	Emergent	Bypass + Primary repair	PTFE	Squamous cell carcinoma	
25	60	M	Rectum	Iliac artery and vein	Emergent	Extra-anatomic bypass grafting	PTFE	Adenocarcinoma	
26	37	F	Soft tissue	Femoral artery and vein	Elective	Reconstruction	Saphena	Leimyosarcoma	Femoral vein thrombosis
27	41	F	Skin	Femoral artery and vein	Elective	Reconstruction	Saphena	Melonoma	
28	62	M	Lung	Subclavian artery	Elective	Extra-anatomic bypass grafting	PTFE	Adenocarcinoma (pancoast tumor)	Pulmonary complications
29	58	M	Lung	Subclavian artery	Elective	Bypass	PTFE	Squamous cell carcinoma (pancoast tumor)	
30	30	M	Chest wall	Subclavian artery and vein	Elective	Bypass	PTFE	Angiosarcoma	
31	66	M	Larynx	Carotid artery	Elective	Reconstruction	Saphena	Squamous cell carcinoma	Acute coronary syndrome
32	60	M	Larynx	Carotid artery	Elective	Reconstruction	Saphena	Squamous cell carcinoma	
33	68	M	Larynx	Carotid artery	Emergent	Reconstruction	Saphena	Squamous cell carcinoma	Cerebral stroke
34	61	F	Larynx	Carotid artery	Emergent	Primary repair	-	Squamous cell carcinoma	
35	65	M	Larynx	Carotid artery	Emergent	Reconstruction	PTFE	Squamous cell carcinoma	
36	67	F	Skin	Carotid artery	Elective	Reconstruction	Saphena	Poorly differentiated epidermoid carcinoma	

M: male; F: female; PTFE: polytetrafluoroethylene.

TABLE II.—*The distribution of tumor localization by organ site of the primary tumor.*

Tumor localization	Number (percent)
Testis	9 (25%)
Larynx	5 (13.9%)
Kidney	4 (11.1%)
Cervix	4 (11.1%)
Lung	2 (5.6%)
Bladder	2 (5.6%)
Rectum	2 (5.6%)
Skin	2 (5.6%)
Soft tissue	1 (2.8%)
Esophagus	1 (2.8%)
Pancreas	1 (2.8%)
Ovary	1 (2.8%)
Chest wall	1 (2.8%)
Total	36

TABLE III.—*The distribution of invaded vessels by the primary tumor.*

Invaded vessel	Number (percent)
Iliac artery	11 (25.6%)
Common iliac artery	6 (13.9%)
External iliac artery	5 (11.6%)
Vena cava inferior	8 (18.6%)
Aorta	6 (13.9%)
Descending thoracic aorta	1 (2.3%)
Abdominal aorta	5 (11.6%)
Carotid artery	6 (13.9%)
Iliac vein	4 (9.3%)
Subclavian artery	3 (6.9%)
Common femoral artery	2 (4.7%)
Femoral vein	2 (4.7%)
Subclavian vein	1 (2.3%)
Total	43

TABLE IV.—*The distribution of vascular intervention s associated with tumor resection.*

Vascular intervention		Number (percent)
Recontruction	Polytetrafluoroethylene (6/18) Saphena (6/18) Dacron® (6/18)	18 (50.0%)
Primary repair		7 (19.4%)
Bypass grafting	Polytetrafluoroethylene (7/7)	7 (19.4%)
Extra-anatomic bypass grafting	Polytetrafluoroethylene (4/4)	4 (11.1%)
Total		36

cava reconstruction because of renal cell carcinoma invasion.

Discussion

The indications for vascular intervention in the surgical treatment of malignancy are two-fold: one is rescue therapy for the unusual intraoperative or immediate postoperative vascular complication, and the other is concomitant resection-reconstruction of major vessels infiltrated by locally advanced cancer. While appropriate treatment is obviously required for the occasional vascular emergency that occurs, many surgeons still consider tumor invasion of vascular structures a relative contraindication to tumor resection.[8, 9] Given the small proportion of cancer patients with major vascular involvement, summative evidence is based upon case series that are heterogenous and often small. The current study was performed to evaluate our clinical experience and surgical results with oncologic procedures associated with major vascular resection and reconstruction on elective or emergent basis.

The surgical literature includes many studies that describe the outcomes for tumors requiring a concomitant major vascular resection and reconstruction. Kelly *et al.* described six patients with large testicular tumors that required en bloc aortic resection and reconstruction for complete tumor resection with no associated vascular-related complications.[10] Vena cava reconstruction for retroperitoneal tumors was shown by Bower *et al.* to be associated with minimal early vascular morbidity and a graft patency of greater than 80%.[11] Pedrazzoli *et al.* reviewed 22 studies, encompassing 841 patients with pancreatic cancer and demonstrated that the addition of a portal vein resection and reconstruction added little to the morbidity and mortality of pancreaticoduodenectomy.[8] Wright *et al.* reported only one major vascular morbidity in 20 patients undergoing oncologic resections that required carotid resection and reconstruction.[12] Koperna *et al.* found that vascular morbidity was 21% in 13 patients who underwent resections

of lower extremity sarcomas that required vascular resection and reconstruction.[13] However, late graft complications were few and limb salvage was possible in patients who otherwise would have required amputation. In contrast, to these favorable reports, Bianchi *et al.* found morbidity and mortality to be significant and substantially increased in patients undergoing a variety of oncologic and concomitant vascular procedures at their institution.[1] However, this report includes not only patients undergoing elective resection of tumors involving vascular structures, but also patients who required a "rescue" vascular procedure to address either a postoperative vascular complication or an unplanned injury to a critical vascular structure at the time of tumor resection. The present study analyzes a single institutional experience in which several vascular techniques were applied to permit resection of a diverse group of neoplasms. Our study includes both patients undergoing an elective resection and also those in whom a vascular procedure was performed to manage an intraoperative or postoperative vascular complication. We found that vascular-related morbidity and mortality were uncommon and overall early complications were comparable to that reported for resection of the tumor alone.

Although vascular interventions were generally associated with elective cancer resection, 14 emergent vascular procedures (38.9%) were required for complications that occurred during or immediately after tumor resection in the present study. Emergent vascular surgery was required during or immediately after tumor resection for 8 cases with isolated major arterial injuries (iliac artery, carotid artery, and aorta), 3 with isolated major venous injuries (vena cava inferior), and 3 with both arterial and venous injuries at the same time (iliac artery and vein). The occurrence of an emergent major vascular complication in conjunction with resective oncologic surgery is particularly uncommon. Pálfalvi et al. reported 13 cases of major vascular injuries in a series of 184 gynecological resections for malignancy.[14] The injured vessels included the external iliac artery (4), the vena cava (3), the external iliac vein (5), and the femoral vein (1). In this study, postoperative complications directly related to the vascular injury occurred in 4 patients (30.8%). These complications included femoral vein thrombosis (2) and iliac artery occlusion (2), which resulted in permanent walking disabilities for both patients. In our study, complications following 4 of the 14 emergent vascular procedures (28.6%) occurred, although only one complication (iliac vein thrombosis) was related to the vascular intervention. Other three complications were pulmonary embolism in two cases and cerebral stroke in one patient.

Overall, none of the patients in the present study died as a direct consequence of a vascular complication that occurred in conjunction with resective oncologic surgery. One patient died on postoperative 27th day due to pulmonary embolism and multiple organ failure that followed emergent inferior vena cava reconstruction because of renal cell carcinoma invasion.

Conclusions

Invasion of major vascular structures has been considered by some a barrier to the removal of large neoplasms. The results reported herein support that the need for resection and reconstruction of a major vascular structure should not prohibit the resection of any given tumor. The study demonstrates that most major vascular reconstructions have a high degree of success, and do not result major complications.

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