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ORIGINAL ARTICLE

Resection of the inferior vena cava for urological malignancies: single-center experience

Shuichi Kato · Toshiaki Tanaka · Hiroshi Kitamura · Naoya Masumori · Toshiro Ito · Nobuyoshi Kawaharada · Taiji Tsukamoto

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Abstract
Background Resection of the inferior vena cava (IVC) is occasionally performed for patients with advanced malignancy in the retroperitoneum. In the current study, we assessed the oncological effectiveness of IVC resection combined with tumor resection. We also addressed peri- and postoperative complications associated with resection and reconstruction of the IVC.
Methods Between 1984 and 2011, a total of 23 patients underwent caval resection concurrently with retroperitoneal tumor excision. Primary tumor histology was renal cell carcinoma in 19 patients, metastatic germ cell tumor in 2, and leiomyosarcoma, and adrenal cancer in 1 patient each. Clinicopathological data from these patients were retrospectively reviewed.
Results IVC reconstruction was performed by direct suture in 11 patients, patch repair in 8 and graft replacement in 3 patients. Interruption of the IVC was performed in one patient. There was no lethal complication or pulmonary embolism. Intracaval thrombosis, although patent, was observed in four patients after surgery. All patients underwent infrarenal IVC reconstruction. The median follow-up was 12 months (range 1–121 months). Of the 20 patients without distant metastasis at the time of surgery, complete resection was achieved in 14, whereas 6 patients had positive margins. Although nine patients developed distant metastases postoperatively, there was no local recurrence. The overall survival, progression-free survival and cause-specific survival in those RCC patients without distant metastasis at the time of surgery were 56.1, 47.0 and 60.4 %, respectively, at 5 years.
Conclusions For advanced malignancies involving the IVC, resection is a safe and feasible procedure for selected patients.

Keywords Inferior vena cava · Tumor thrombus · Urological malignancies

S. Kato · T. Tanaka (✉) · H. Kitamura · N. Masumori · T. Tsukamoto
Department of Urology, Sapporo Medical University School of Medicine, S-1, W-16, Chuo-ku, Sapporo 060-8543, Japan
e-mail: ttoshi@sapmed.ac.jp

T. Ito · N. Kawaharada
Department of Thoracic and Cardiovascular Surgery, Sapporo Medical University School of Medicine, Sapporo, Japan

Introduction

Some urological malignancies involve the inferior vena cava (IVC) and require its resection for surgical cure. Postchemotherapy retroperitoneal lymph node dissection (PC-RPLND) for bulky retroperitoneal metastases of germ cell tumors (GCTs) may require IVC resection [1–3]. Renal cell carcinoma (RCC) is known to develop tumor thrombus extension into the IVC in 4–10 % of patients [4]. In cases with a tumor thrombus invading the IVC wall, extensive resection of the caval wall to achieve negative surgical margins is necessary to improve survival [5]. The development of innovative surgical techniques, specifically the application of liver transplant techniques and the adoption of cardiopulmonary bypass, have improved the safety and completeness of those challenging procedures [6–8]. However, there is controversy regarding the necessity of reconstruction after IVC resection. IVC ligation or interruption may induce renal failure and lower extremity edema (LEE) in the event that sufficient collaterals are lacking [1, 9]. For reconstruction, patch venoplasty or graft interposition is attempted via various procedures [9, 10]. In

the current study, we detail our experience at our institute of IVC resection with and without reconstruction for patients with locally advanced renal tumors, bulky metastatic GCTs and other retroperitoneal tumors, including adrenal carcinoma and sarcoma.

Patients and methods

From an institutional review board-approved database at a single institution from 1984 to 2011, we identified 23 patients who underwent surgical exploration with concomitant IVC resection for malignancy. Of the 23 patients, 19 had RCC, 2 had metastatic GCT, 1 had leiomyosarcoma of the right kidney, and 1 had left adrenal cancer. Twenty-two patients were male, and 1 patient was female; their mean age was 61 years (range 32–81 years).

Preoperatively, all patients underwent either computed tomography (CT) or magnetic resonance imaging (MRI) to assess the cephalic extent of the thrombus and determine whether complete or incomplete IVC obstruction was evident. The operations were carried out by urological and vascular surgeons. The IVC was exposed and secured with vessel loops superiorly and inferiorly to the thrombus. The renal vein and lumbar veins were also secured. Subsequently, patients underwent systemic heparinization. After confirming prolongation of activated coagulation time, we clamped the vessels and started resection of the IVC. The procedure for resection and reconstruction of the IVC was chosen according to the clinical, radiological and intraoperative findings—partial wall resection with a direct running suture or prosthetic patch repair, circumferential cavectomy with graft replacement, or interruption without reconstruction.

Patient charts were reviewed for the presentation of clinical signs and symptoms, perioperative therapy, tumor histology and margin status, intraoperative findings and management, complications, cancer recurrence and survival.

In cases of RCC without distant metastasis, oncological outcomes were also evaluated. The overall survival (OS), progression-free survival (PFS) and cause-specific survival (CSS) were estimated using Kaplan–Meier curves, and the differences were determined by log-rank test. P values <0.05 were considered significant.

Results

Patient characteristics are summarized in Table 1. Of 19 patients with RCC, 16 had no metastasis (nos. 1–16), whereas 3 had distant metastasis (nos. 17–19) at the time of surgery. Preoperative radiographical diagnoses revealed complete IVC obstruction in eight patients. Partial caval wall resection was performed in 19 patients; the caval wall was closed by direct suture in 11 and prosthetic patch grafting in 8. For patch repair, polytetrafluoroethylene (PTFE) grafts and a Dacron graft were used in 7 patients and 1 patient, respectively. In 3 patients, circumferential tumor invasion of the IVC wall required segmental cavectomy and replacement with an expanded PTFE graft. In the other one patient, the completely occluded IVC with a tumor thrombus was removed without reconstruction. The site of the IVC reconstruction was suprarenal in 8 patients, infrarenal in 2 and both suprarenal and infrarenal in 12.

Radiographic diagnoses were consistent with intraoperative findings on the level of the tumor thrombus, but not on tumor invasion of the IVC wall. Therefore, the final decision for the surgical procedure was made based on intraoperative findings.

Postoperatively, anticoagulation was performed in 11 patients; warfarin was used in 9 and acetylsalicylic acid in 2. No patient needed reoperation and no death associated with the operation was observed. There was no patient with intraoperative or postoperative pulmonary embolism, or postoperative LEE. Four patients developed thrombosis in the IVC after the surgery; all of them underwent infrarenal IVC reconstruction with a tubular prosthetic PTFE graft for segmental cavectomy in 2, patch repair with a Dacron graft in 1 and direct suture in 1. Of these 4 patients, 2 needed permanent placement of an IVC filter to prevent pulmonary embolism on day 7 postoperatively.

Of 16 RCC patients without preoperative distant metastasis, complete resection of the primary tumor was achieved in 12 patients, and 4 had microscopically positive surgical margins without distant metastasis. The 5-year OS, PFS, CSS rates in the RCC patients without distant metastasis at the time of surgery were 56.1, 47.0 and 60.4 %, respectively. The OS was significantly better in those who obtained complete resection than in those with positive margin ($P = 0.023$), as shown in Fig. 1.

Discussion

Involvement of the IVC is occasionally observed in urological malignancies. Resection of the IVC is required in 6–12 % of patients undergoing PC-RPLND for GCTs [1–3, 11], and 15–25 % of those undergoing nephrectomy for RCC with an intracaval tumor thrombus [11, 12]. Extrinsic or intrinsic IVC involvement may also arise from primary retroperitoneal tumors and adrenal tumors [2, 9].

According to clinical, radiological and intraoperative findings, the procedure for resection and reconstruction of the IVC was determined. We performed partial wall resection with a direct running suture or patch repair,

Table 1 Patient characteristics and surgical outcome

Patient no.	Age	Sex	Tumor type	Preoperative metastasis	Preoperative IVC obstruction	Level of the IVC reconstruction	Reconstruction	Margin status	Anticoagulation	Thrombus formation	Recurrence site	Follow-up (months)	Outcome
1	75	M	Rt RCC	None	Complete	Supra + infrarenal	Direct suture	Negative	+	+	None	79	NED
2	72	M	Lt RCC	None	None	Suprarenal	Direct suture	Negative	None	None	None	66	NED
3	60	M	Rt RCC	None	None	Supra + infrarenal	Direct suture	Negative	None	None	None	63	NED
4	57	M	Lt RCC	None	None	Suprarenal	Direct suture	Negative	None	None	Liver	12	AWD
5	56	M	Rt RCC	None	None	Supra + infrarenal	Direct suture	Negative	None	None	None	10	NED
6	68	M	Rt RCC	None	Complete	Supra + infrarenal	Direct suture	Positive	None	None	Lung	9	DOD
7	43	M	Rt RCC	None	None	Suprarenal	Direct suture	Negative	None	None	None	2	NED
8	61	M	Rt RCC	None	None	Supra + infrarenal	Direct suture	Negative	None	None	None	1	NED
9	46	M	Lt RCC	None	None	Suprarenal	Patch PTFE	Negative	None	None	None	121	NED
10	71	M	Lt RCC	None	Complete	Suprarenal	Patch PTFE	Negative	+	None	None	57	NED
11	62	M	Lt RCC	None	Complete	Supra + infrarenal	Patch PTFE	Negative	+	None	Bone	12	AWD
12	81	M	Rt RCC	None	None	Suprarenal	Patch PTFE	Negative	+	None	Liver	10	DOD
13	46	M	Bil RCC	None	None	Suprarenal	Patch PTFE	Positive	None	None	None	10	NED
14	55	M	Bil RCC	None	Complete	Supra + infrarenal	Patch PTFE	Positive	+	None	None	7	DOC
15	70	M	Lt RCC	None	Complete	Supra + infrarenal	Replacement PTFE	Positive	+	None	Bone	18	DOD
16	81	M	Rt RCC	None	Complete	Supra + infrarenal	Replacement PTFE	Negative	+	+	Liver, LN	13	DOD
17	47	M	Rt RCC	Liver, lung	None	Supra + infrarenal	Direct suture	Negative	None	None	Liver	64	AWD
18	65	M	Rt RCC	Liver	None	Supra + infrarenal	Patch PTFE	Positive	None	None	Liver	1	DOD
19	62	M	Rt RCC	Liver, lung	Complete	–	None	Positive	None	None	Liver, lung	5	DOD
20	45	M	NSGCT	RPLN	None	Infrarenal	Replacement PTFE	Positive	+	+	RPLN	24	DOD
21	32	M	NSGCT	RPLN	None	Infrarenal	Direct suture	Negative	+	None	None	15	NED
22	65	M	Rt LMS	None	None	Supra + infrarenal	Patch Dacron	Negative	+	+	Liver, bone	9	AWD
23	51	F	Rt ACC	None	None	Suprarenal	Direct suture	Positive	+	None	Lt kidney	7	AWD

IVC inferior vena cava, *RCC* renal cell carcinoma, *NSGCT* nonseminomatous germ cell tumor, *LMS* leiomyosarcoma, *ACC* adrenocortical carcinoma, *PTFE* polytetrafluoroethylene, *NED* no evidence of disease, *AWD* alive with disease, *DOD* died of disease, *DOC* died of other causes

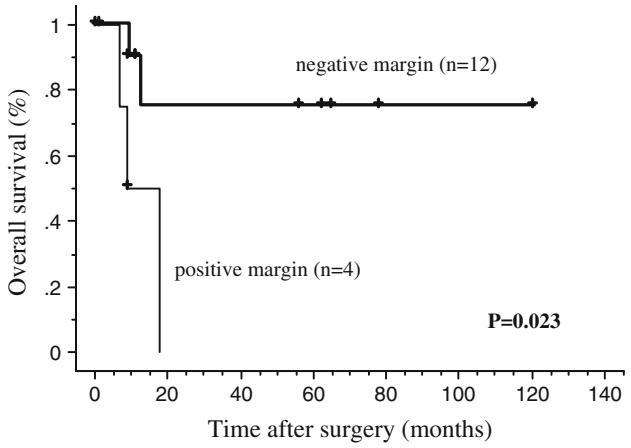

Fig. 1 Overall survival stratified according to margin status

circumferential cavectomy with graft replacement, or interruption without reconstruction [13]. Lesions involving less than half the circumference of the IVC may be controlled by partial cavotomy with primary closure or patch closure, whereas more invasive ones need circumferential resection of the IVC [14]. Precise preoperative evaluation of the extent of tumor invasion into the vena caval wall is difficult. Although multi-detector row CT and MRI are sensitive for determining the level of the tumor thrombus, they might not differentiate between simple tumor thrombus and its invasion into the vena cava [15]. In addition, thrombi can progress rapidly from the time of the radiographic examinations [16]. Therefore, the final decision on the surgical procedure needs to be made based on intraoperative findings.

Biosynthetic and autogenous tissue grafts using a vein, pericardium or peritoneal fascia are preferred for patch repair in patients who need concurrent surgeries with a high risk of infection such as hepatectomy and bowel resection [17]. On the other hand, patch repair with a prosthetic graft provides patency and negligible complications [16–18]. In our series, all patients who underwent patch repair with a PTFE graft showed favorable functional outcomes with no infectious complications. In aseptic operations, prosthetic materials can be utilized safely.

There is controversy regarding the necessity for reconstruction after circumferential resection. IVC reconstruction is not required in selected patients, because collateral veins are sufficiently developed to drain the venous return from the lower extremities and pelvic region [11, 19, 20]. However, LEE is a frequent harmful complication associated with interruption of the IVC [18]. Duty et al. [11] reported that of 6 patients who underwent IVC ligation, 4 had postoperative LEE at discharge; however, the time to resolution ranged from 2 weeks to 14 months. To prevent postoperative LEE, some investigators advocate replacement of the IVC with a graft after the interruption in patients with poor development of collateral circulation [18], or even those with complete IVC obstruction and adequate radiographic evidence of venous collaterals [21, 22]. A ringed PTFE graft is usually used for replacement of the IVC [11]. In our series, reconstruction of the IVC with a PTFE graft was successfully performed with consistent patency and no infectious events as reported in the literature [19, 22]. Although the risk of thrombosis needs to be considered, IVC replacement with a PTFE graft may be a safe and feasible procedure for patients with extensive disease involving the IVC.

Hardwigsen et al. [23] reported that thrombosis developed within the prosthetic graft at infrarenal sites after surgery in 2 of 8 patients who underwent IVC reconstruction. Our results were consistent with that report. All of those who developed thrombosis had undergone reconstruction of the IVC below the entry of the renal vein, whereas no patient with reconstruction limited to the suprarenal segment developed thrombosis. These findings suggested that the flow from the renal vein contributed to prevention of thrombus formation. Although its routine administration remains controversial [23, 24], postoperative anticoagulation therapy should be considered for those who receive infrarenal IVC reconstruction. Preoperative radiographic diagnoses revealed complete IVC obstruction in eight patients, 2 of whom developed thrombosis postoperatively. The degree of IVC obstruction did not predict postoperative formation of the thrombosis.

The surgical mortality resulting from hemorrhage, disseminated coagulation, renal failure, and pulmonary embolism ranged from 2.7 to 13 % [5, 25]. In our series, however, there was no patient with pulmonary embolism and any other lethal complication. Extremely progressive disease might be considered inoperable and surgical treatment abandoned. Because the data were collected in a retrospective manner, the criteria for the judgment were not standardized. This selection bias may be an explanation for the difference of mortality rates between other reports and our series.

In RCC, aggressive resection of disease involving the IVC with a negative margin provides a better oncological outcome [5, 14–16]. Complete resection of retroperitoneal sarcoma [17] or adrenal carcinoma [18] with thrombectomy is the only curative management. The 5-year OS of patients with T3 RCC undergoing complete resection ranged from 30 to 72 % [5, 25, 26]. The 5-year PFS and CSS in T3 RCC patients without distant metastasis at the time of surgery were 35 and 58 %, respectively [27, 28]. These results coincide with our series. In this study, we demonstrated the safety and feasibility of radical surgery including IVC resection for patients with locally advanced urological malignancies. Thus, an aggressive surgical

strategy should be considered for disease control and prolonged survival in patients with these malignancies.

Conflict of interest The authors declare that they have no conflict of interest.

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