The safety and validity of surgical resection for hemodialysis-dependent patients with renal cell carcinomas involving the inferior vena cava

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Abstract Perioperative morbidity and mortality increase during renal cell carcinoma resection with inferior vena cava involvement in hemodialysis-dependent end-stage renal disease patients. We evaluated the safety and validity of surgical management for renal cell carcinoma with inferior vena cava thrombi in such patients undergoing radical nephrectomies and tumor thrombectomies. There were three patients with tumor thrombus level II, and one each with tumor thrombus level III and IV. We evaluated median operative time (337 min), median estimated blood loss (1300 mL), and median postoperative hospitalization (15 days). Postoperative complications included surgical site dehiscence and pulmonary thromboembolism. One patient with preoperatively identified lung metastases developed a pulmonary thromboembolism on day 3 and died on day 15. The other four patients had long postoperative survival (19–104 months). Successful surgical management of renal cell carcinoma involving the inferior vena cava requires preoperative evaluation of the patient's condition to improve survival for hemodialysis-dependent end-stage renal disease patients.

Keywords Hemodialysis · Inferior vena cava · Renal neoplasms · Tumor thrombectomy · Tumor thrombosis

Introduction

Renal cell carcinomas (RCCs) involve inferior vena cavae (IVC) in 4 % of patients, and extend into the right atrium in 1 % of patients [1–3]. Surgical resection is the only curative treatment for RCC involving IVC with or without atrial thrombi. However, the surgery is technically challenging and demanding, and perioperative morbidity and mortality rates can be as high as 70 and 2.7–13.0 %, respectively, because of blood loss, renal dysfunction, and cardiovascular complications [4–6].

Perioperative complication rates are higher in hemodialysis-dependent end-stage renal disease (ESRD) patients. Indeed, ESRD is an independent risk factor for postoperative death and cardiac events, and the all-cause mortality rate in ESRD patients is 6.4–7.8-fold higher than that in the general population [7].

Reports that describe the surgical management of RCC with IVC thrombi in hemodialysis-dependent patients are scarce. We document our perioperative outcomes in this case analysis.

Case report

Patients

A total of 123 patients were identified as having RCC with IVC involvement at our institution between 1985 and 2014. The American Joint Committee on Cancer Staging criteria were used for tumor staging [8]. Pathological diagnosis was made according to the 2004 World Health Organization classification, and the Fuhrman criteria were used to grade the tumors histopathologically [9, 10]. One hundred and six patients were managed surgically with radical

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nephrectomies and IVC thrombectomies, and, of these, five patients had hemodialysis-dependent ESRD.

The patients' preoperative management included computed tomography (CT) imaging of the abdomen. The cephalic extents of the tumor thrombi were evaluated using multi-detector CT and/or magnetic resonance imaging, and transesophageal echocardiography. The tumor thrombus levels were evaluated using the Mayo classification [11]. Cardiac function was evaluated using electrocardiography, echocardiography, and, if necessary, myocardial scintigraphy and coronary angiography. Patients with a recent history of myocardial infarction, ongoing cardiac ischemia, severe valve dysfunction, or ejection fraction <40 % were not indicated for surgery. Hemodialysis was performed the day before surgery. An IVC filter was placed on the day of surgery. A postoperative complication was defined as any complication that occurred within 30 days of surgery [12].

Surgery

The surgical procedure was not specific to hemodialysis-dependent ESRD patients. Radical nephrectomies and thrombectomies were performed via a midline abdominal incision from the xiphisternum to the symphysis pubis. After the colon was mobilized, the kidney, bilateral renal veins, and IVC were completely dissected. The proximal and distal IVC and the opposite side of the renal vein were clamped, the IVC was incised, and the thrombus was removed. The IVC was repaired using 3-0 non-absorbable monofilament sutures. For patients with level III thrombi, liver mobilization was performed based on the liver transplantation technique. The porta hepatis was controlled with a sling tourniquet to reduce venous backflow from the hepatic veins. For patients with level IV thrombi, a median sternotomy was made and a thrombectomy that involved a cardiopulmonary bypass and deep hypothermic cardiac arrest was undertaken. All patients were managed in the intensive care unit (ICU) until postoperative day 1 or 2. In general, hemodialysis was carried out on day 1 postoperatively. As part of intra-operative management, invasive monitoring, including central venous pressure and arterial pressure, was used. Postoperatively, the patients required meticulous monitoring in the ICU depending on the extent of the surgery, because excessive bleeding might occur, especially in patients who underwent surgery for level IV thrombi. The fluid and electrolyte balances were corrected with arterial blood sampling every 3 h, especially for intraoperative excessive fluid and blood transfusions.

Table 1 summarizes the patients' demographic and clinical characteristics. All patients were male, and all of the tumors were right-sided. Two patients had lung metastases. The Eastern Cooperative Oncology Group Performance Status (ECOG PS) score was 2 in one patient

and 0 in four patients. The median hemodialysis duration was 16 years (range 7.2–37).

The median operative time was 337 min (range 268–399), the median estimated blood loss was 1300 mL (range 1132–3320), and the median postoperative hospital stay was 15 days (range 9–110).

Arrhythmia was identified as a postoperative complication, and it was managed with medication. The patient who had a level IV thrombus experienced surgical site dehiscence that required surgical repair. A pulmonary thromboembolism (PTE) with pleural effusion occurred on postoperative day 3 in one of the patients who had lung metastases. Anticoagulant medication administered after the diagnosis of PTE was ineffective, and the patient died on postoperative day 15. Risk stratification for PTE was performed using Caprini classification preoperatively, and mechanical prophylaxis (i.e., intermittent pneumatic compression) was performed according to the indication. Pharmacological prophylaxis (i.e., heparinization) was not selected due to the nature of surgery, in which excessive bleeding was anticipated [13, 14].

The median follow-up duration was 21 months (range 1–104). One patient died from cancer 25 months after surgery, and three patients were alive and had no evidence of disease at the end of the study period.

Discussion

For patients with locally advanced RCC, an aggressive surgical approach is the only curative option, and it is likely to offer a better chance of prolonged survival. Maxwell et al. [15] reported that the median overall survival for inoperable RCC patients was 6 months. Many authors have described the perioperative outcomes and long-term survival rates for these patients, and a radical nephrectomy with an IVC tumor thrombectomy has become the standard of care [1, 16, 17]. Despite advances in surgical techniques and equipment, perioperative morbidity and mortality can be as high as 70 and 3–16 %, respectively [4–6]. The 5-year cancer-specific survival (CSS) rate for patients with RCC with IVC thrombi ranges from 33 to 59 % [2, 17, 18]. We previously described 68 cases of RCC with IVC thrombi, and the perioperative mortality rate was 7 %, the median CSS rate was 27.2 months, and the 5-year CSS rate was 36.7 %. We have achieved acceptable complication and long-term survival rates that are comparable with those of other high-volume centers [19].

Chronic kidney disease is an independent risk factor for postoperative death and cardiac events [20], and cardiovascular disease remains the most frequent cause of death in hemodialysis-dependent patients. Hence, effective

Table 1 Demographic and clinical characteristics of the patients

Characteristic	Patient number				
	1	2	3	4	5
Age (years)	54	50	61	69	67
Sex	Male	Male	Male	Male	Male
Tumor laterality	Right	Right	Right	Right	Right
BMI (kg/m ²)	20	22	17	26	19
ECOG PS	0	0	0	0	2
ASA score	3	3	3	3	3
Symptom	Hematuria	Back pain, hematuria	None	Weight loss	Back pain
Cause of renal dysfunction	Chronic glomerulonephritis	DM nephritis	Chronic glomerulonephritis	Chronic glomerulonephritis	IgA nephritis
TNM classification	T3bN0M0	T3bN0M1 (lung)	T3bN0M0	T3bN1M0	T3bN0M1 (lung)
Tumor size (mm)	82	70	67	78	83
Hemodialysis duration (years)	16	14	37	7.2	20
Tumor thrombus level	Level III	Level II	Level IV	Level II	Level II
Operative time (min)	268	399	531	337	229
Estimate blood loss (mL)	1400	1300	3320	1488	1130
Clavien–Dindo complication classification	II: arrhythmia		III: wound dehiscence		V: pulmonary embolism
Hospital stay (days)	18	11	110	9	15
Histologic subtype	Clear cell	Clear cell	Papillary	Papillary	Clear cell
Fuhrman grade	2	3	3	3	3
Follow-up duration (months)	104	25	21	19	1
Outcome	NED	Cancer death	NED	NED	Operative death

BMI body mass index, *ECOG PS* Eastern Cooperative Oncology Group Performance Status, *ASA* American Society of Anesthesiologists, *DM* diabetes mellitus, *TNM* tumor, node, metastasis classification of malignant tumors, *NED* no evidence of disease

cooperation and communication among nephrologists, anesthesiologists, and surgeons are indispensable. As the perioperative management of hemodialysis-dependent patients has improved and become standardized, the number of reports that describe surgery performed on hemodialysis-dependent patients that has been managed safely has increased, and the perioperative complication rates are as low as those in the general population [21, 22].

Our institution has optimized the perioperative management of hemodialysis patients, and cooperation and communication between the nephrologists and surgeons are well organized. We previously described 408 hemodialysis-dependent patients who underwent radical nephrectomies at our center between 1979 and 2013 [21]. Additionally, we have also performed 106 radical nephrectomies in patients who had RCC with IVC thrombi, and the surgical technique has been standardized, as described above. Given the high mortality and morbidity rates associated with this extensive surgery, the careful selection of patients who will undergo surgery is extremely important. However, there are no definitive indications for surgery, and decision-making largely depends on the

surgeons' preferences. In our series of five hemodialysis-dependent patients, surgical site dehiscence that required surgical repair occurred in one patient who had a level IV tumor thrombus. Surgical site dehiscence might be caused by the undernourished status of hemodialysis-dependent patients. One of the patients with a level II tumor thrombus and lung metastases developed a PTE on postoperative day 3 and died on postoperative day 15. This patient had a malignant pleural effusion in the right thorax before surgery, and his ECOG PS score was 2. He might have been an inappropriate candidate for surgery. His general condition might have been associated with this outcome. On the other hand, the other four patients were successfully managed during the perioperative period and achieved long-term survival. One survived for 25 months after surgery, and three of them have survived over respective follow-up periods of 19, 21, and 104 months. These four patients had an ECOG PS score of 0 before surgery, suggesting that the preoperative condition may predict prognosis after surgery. Abel et al. reported the preoperative predictors of major complications after surgery in patients with IVC thrombi. They analyzed 162 patients with levels

III or IV thrombi. Of these patients, 17 were dead within 90 days of surgery, and the authors concluded that an ECOG PS score of >1 or a low serum albumin level are risk factors for perioperative mortality [23].

Surgical equipment has improved and the techniques have become more refined during this era of minimally invasive surgery. Gill et al. described 16 patients who had undergone robotic IVC thrombectomies. All of the robotic IVC thrombectomies (level II thrombi: 7, level III thrombi: 9 cases) were performed successfully without any open conversions [24]. Therefore, even extensive surgery, including that for tumor thrombi, can be performed safely, and high-risk patients, such as hemodialysis-dependent patients, could benefit immensely.

In conclusion, an aggressive surgical approach for RCC with IVC thrombi is effective for patients with good performance status before surgery, even for hemodialysis-dependent patients.

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Compliance with ethical standards

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

Ethical approval Institutional review board approval was obtained to retrospectively analyze the patients' data. Additionally, this study conformed to the Declaration of Helsinki.

Informed consent Informed consent was obtained from all individual participants included in the study.

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