



Surgical Treatment of Renal Cell Carcinoma with Inferior Vena Cava Invasion

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Abstract

Renal cell carcinoma (RCC) is the most common malignant tumor involving the inferior vena cava (IVC), and intraluminal tumor thrombus is associated with poor prognosis without surgical treatment. We retrospectively analyzed five consecutive patients with RCC and IVC involvement treated between 2020 and 2026. One patient had Mayo level 0 thrombus, three had level I, and one had level II.

All patients underwent radical nephrectomy with tumor thrombectomy and IVC reconstruction, including lateral venorrhaphy (3), bovine pericardial patch angioplasty (1), and suprarenal IVC replacement with an 18-mm Dacron graft (1).

There were no major postoperative complications or 30-day mortality. During a mean follow-up of 34 months (range, 3–60), no local recurrence or distant metastases were observed and overall survival was 100%. Radical surgery performed by an experienced multidisciplinary team can achieve favorable early and mid-term outcomes in carefully selected patients with RCC and IVC invasion.

Keywords: Renal Cell Carcinoma; Inferior Vena Cava; Tumor Thrombus; Mayo Classification; IVC Reconstruction

Abbreviations

RCC: Renal Cell Carcinoma; IVC: Inferior Vena Cava; MDCT: Multidetector Computed Tomography; LMWH: low-Molecular-Weight Heparin.

Introduction

Approximately 4–14% of renal cell carcinoma cases develop a tumor thrombus extending into the inferior vena cava [1-5]. Although there may be no macroscopic invasion of the venous wall, the presence of intraluminal tumor thrombus indicates increased biological aggressiveness of RCC, and survival without surgery is often less than one year due to the risk of massive pulmonary embolism. Therefore, radical surgical treatment is the only therapeutic option for patients with RCC extending into the IVC, even in the presence of limited distant metastases [1,4,5,6].

Case Series

This was a retrospective single-center case series of patients with renal cell carcinoma (RCC) and inferior vena cava (IVC) invasion treated at a tertiary referral center between January 2020 and January 2026. All consecutive patients who underwent radical nephrectomy with tumor thrombus removal and IVC reconstruction during the study period were included. Demographic data, clinical-pathological findings, surgical treatment, perioperative complications, and early and mid-term results were analysed.

This study was conducted in accordance with institutional ethical standards and the Declaration of Helsinki. Written informed consent for publication was obtained from all patients.

The average age of five treated patients was 56.4 years (range 49–65), and most were men (80%). One patient (20%) had arterial hypertension and another (20%) had dyslipidemia. The right kidney was affected by RCC in four (80%), while the left kidney was affected in one (20%) case. The clinical presentation included back pain in four patients (80%), weight loss in one (20%) and hematuria in two patients (40%). In addition to standard clinical examination, all patients underwent MDCT angiography. According to the Mayo classification, one patient (20%) had level 0 thrombus, three patients (60%) had level I and one patient (20%) had level II thrombus. Demographic characteristics, comorbidities, clinical presentation and Mayo classification are presented in Table 1 and Figure 1.

Demographic characteristics	N (%)
Age	56.4 (49-65) years
Sex	
Male	4 (80%)
Female	1 (20%)
Comorbidities	
Arterial Hypertension	1 (20%)
Dyslipidemia	1 (20%)
Clinical Presentation	
Back Pain	4 (80%)
Weight Loss	1 (20%)
Hematuria	2(40%)
Affected Kidney	
Right	4 (80%)
Left	1 (20%)
Mayo Classification	
Type 0	1 (20%)
Type I	3 (60%)
Type II	1 (20%)
Type III	0 (0%)
Type IV	0 (0%)

Table 1: Demographic characteristics, comorbidities, clinical presentation and Mayo classification.

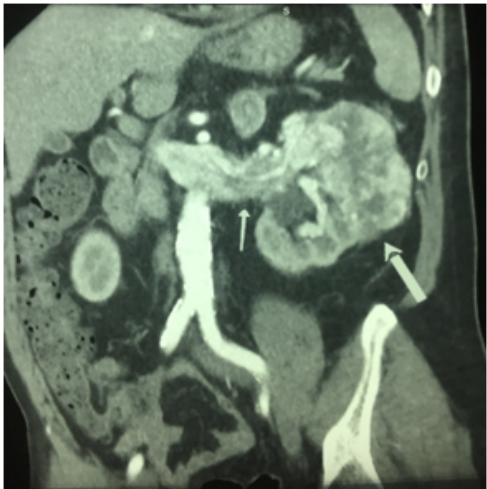


Figure 1: MDCT angiography showing RCC of the left kidney with tumor thrombus extending into the left renal vein.

Surgical treatment, including radical nephrectomy, removal of the tumor thrombus and an IVC procedure, was performed under general anesthesia. A midline laparotomy approach was used in one patient (20%), lumbotomy in two patients (40%) and a modified Chevron incision in two patients (40%). Radical nephrectomy began with ligation and division of the corresponding renal artery as close as possible to its origin from the abdominal aorta. The renal vein was then resected, and the ureter was divided as close as possible to the bladder. Exposure of the left kidney required mobilization of the left colon, whereas mobilization and medial rotation of the right colon and mesenteric root using the Kocher maneuver were performed to expose the right kidney. Nephrectomy was followed by removal of the affected perirenal fatty tissue and surrounding lymphatic tissue.

The procedure on the IVC was then performed. It consisted of resection of the involved renal vein, followed by partial clamping of the IVC and lateral venorrhaphy in three patients (one with Mayo level 0 and two with Mayo level I thrombi). In one patient (20%) with Mayo level I thrombus and dense adherence of the tumor thrombus to the IVC wall, complete removal of the thrombus required partial resection of the IVC under suprarenal cross-clamping. The resulting IVC defect was reconstructed using a bovine pericardial patch angioplasty (Figure 2).

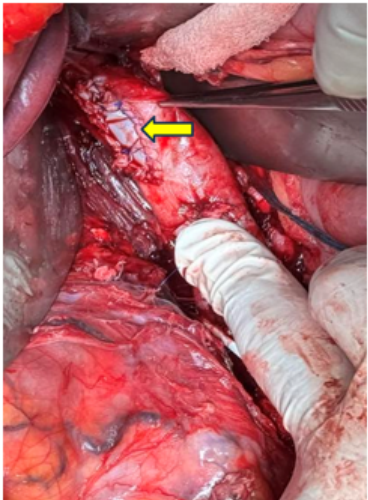


Figure 2: Bovine pericardial patch angioplasty (yellow arrow) of the IVC following tumor thrombus removal and partial resection of the IVC wall.

In one patient (20%) with Mayo level II disease, removal of the tumor thrombus required suprarenal crossclamping of the IVC and its segmental excision. Surgical approaches and IVC procedures are summarized in Table 2. In this case, IVC replacement was performed with an 18mm tube Dacron graft, including the confluence of the left renal vein in the proximal anastomosis (Figure 3).

	N (%)
Surgical Approach	
Medial Laparotomy	1 (20%)
Lumbotomy	2 (40%)
Chevron	2 (40%)
Procedure with Inferior Vena Cava	
Suture	3 (60%)
Patch Angioplasty	1 (20%)
Graft Interposition	1 (20%)

Table 2: Surgical approaches and IVC procedures.

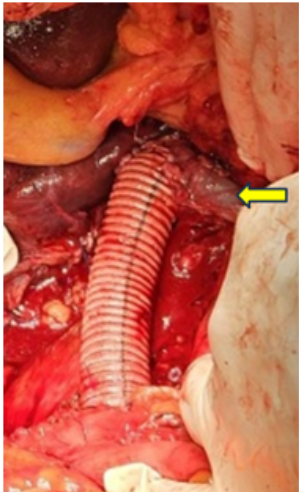


Figure 3: IVC replacement with an 18-mm Dacron tube graft. The confluence of the left renal vein was incorporated into the proximal anastomosis (yellow arrow).

Histopathological analysis of the removed kidneys confirmed RCC in all cases. All patients received lowmolecularweight heparin (LMWH) during the first three postoperative days, together with intermittent pneumatic compression of the lower extremities. Patients who underwent patch angioplasty or IVC replacement with prosthetic graft were discharged on oral anticoagulants for six months, followed by aspirin thereafter.

No major postoperative complications or 30-day mortality were recorded. Patients underwent annual CT scans of the abdomen and chest during followup. After a mean followup period of 34.2 months (range 3–60), there was no local recurrence or distant metastases, and overall survival was 100%.

Discussion

According to the Mayo classification, which is based on the cranial extent of tumor thrombus, RCCs with IVC invasion are divided into five groups. Mayo level 0 includes thrombus limited to the renal vein. Mayo level I denotes thrombus extending into the IVC but not more than 2 cm above the renal vein. In Mayo level II, the tumor thrombus extends into the IVC more than 2 cm above the renal vein but not to the hepatic veins. In Mayo level III, the thrombus extends into the IVC above the hepatic veins but not to the diaphragm, and in Mayo level IV the thrombus extends into the supradiaphragmatic IVC or right atrium. Mayo levels 0 and I are the most common and occur in 50–60% of cases, levels II and III in 30–40%, while level IV is the rarest (5–10%) [4,5]. In our series, one patient (20%) had level 0, three (60%) level I and one (20%) level II thrombus (Figure 4).

Surgical treatment is practically the only option for patients with RCC and IVC invasion who do not have significant comorbidities [4–6]. The operative strategy depends on the cranial extension of the tumor thrombus, the degree of IVC obstruction and the development of collateral veins [5,6].

The surgical approach depends on thrombus level. In RCC with Mayo levels 0 and I, supra and infraumbilical midline laparotomy is recommended, followed by medial rotation of the right colon and mesenteric base [5,7]. This allows exposure of the right kidney as well as the infrarenal and initial suprarenal segments of the IVC

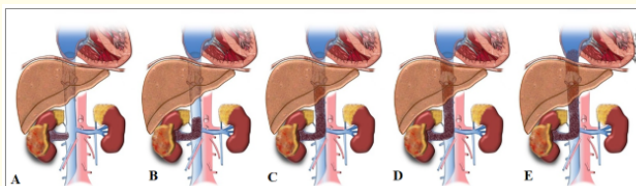


Figure 4: Mayo clasification of RCCs according to the level of tumor thrombus extension. A. The level 0: Tumor thrombus extending to renal vein only. B. The level I: Tumor thrombus extending into the IVC but not more than 2 cm above renal veins. C. The level II: Tumor thrombus extending into the IVC to more than 2 cm above the renal veins but not to the hepatic veins. D. The level III: Tumor thrombus extending into the IVC above the hepatic veins but not to the diaphragm. E. level IV: Tumor thrombus extending itnto the supradiaphtagmatic IVC or right atrium.

(Figure 5). If the left kidney is affected, mobilization of the left colon is required first.

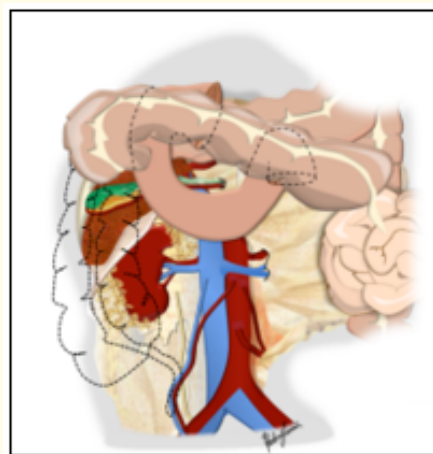


Figure 5: Medial rotation of the right colon and mesenteric base allows exposure of the right kidney, as well as infrarenal and initial suprarenal part of the IVC [5,7].

For RCC with Mayo levels II and III, most authors recommend a bilateral subcostal or modified Chevron incision [5,7]. In addition to mobilization and medial rotation of the right colon and mesenteric base, mobilization of the first portion of the duodenum

using the Kocher maneuver is necessary to expose the suprarenal infrahepatic segment of the IVC (Figure 6) [5,7,8].

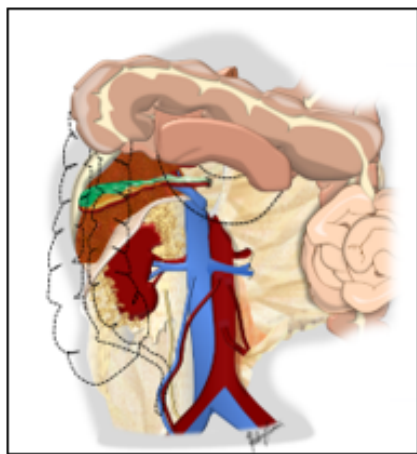


Figure 6: Medial mobilization of the right colon and mesenteric root and mobilization of the first portion of the duodenum using the Kocher maneuver, allowing exposure of the suprarenal and infrahepatic segment of the IVC [5,7,8].

In our small series surgical approach included midline laparotomy in one (20%) case, lumbotomy in two (40%) cases, as well as modified Chevron incision in two (40%) cases.

Since we did not have patients with retrohepatic or supradiaphragmatic thrombus extension, access to the retrohepatic segment of the IVC and the additional procedures required for Mayo levels III and IV are not discussed in detail here [5,7,8].

After exposure of the kidney and the corresponding IVC segment, the first operative step is nephrectomy of the affected kidney. We recommend ligation and transection of the renal artery as close as possible to its origin from the abdominal aorta to reduce intraoperative bleeding. Preoperative embolization of the renal artery is seldom used because it prolongs treatment and requires delayed surgery to allow thrombosis within the kidney. Radical nephrectomy is followed by extraction of the tumor thrombus from the IVC.

In RCC with Mayo level 0, tumor thrombus removal can be performed under partial clamping of the IVC. After resection of the renal vein filled with thrombus, lateral suturing of the IVC can be

performed, as in 60% of our cases. Mayo levels I–III usually require crossclamping of the IVC above and below the thrombus [5].

When the thrombus is very adherent, a portion of the IVC wall must be resected. In such cases, patch angioplasty is recommended to avoid significant stenosis and late thrombosis [5,6]. We performed bovine pericardial patch angioplasty of the IVC in one (20%) of our patients (Figure 2). Segmental resection of the IVC affected by tumor thrombus is relatively rare but may be unavoidable in cases with extensive wall involvement. If the suprarenal segment of the IVC must be resected, graft replacement is necessary to avoid acute renal failure and severe lower limb edema [9–11]. Replacement of the infrarenal IVC during treatment of primary or secondary malignancies is indicated when the IVC was patent preoperatively, when collateral circulation appears inadequate after caval resection and when important collateral veins must be ligated or resected during tumor removal [5,6,7,11]. We performed tube Dacron graft replacement of the infrarenal IVC in one (20%) of our patients (Figure 3).

Patients who undergo IVC replacement with prosthetic graft should receive LMWH during the first three postoperative days, followed by oral anticoagulants for six months and aspirin thereafter [5,11]. Lower extremity pneumatic compression is also recommended in the early postoperative period.

We had no cases of perioperative mortality. According to review articles published in the last 10 years, perioperative mortality after surgical treatment of RCC with IVC invasion ranges from 0.8% to 38% [12–16]. Reported fiveyear survival in patients without distant metastases ranges from 30% to 71.4% [12–16]. In our series, overall survival was 100% after a mean followup of 34.2 months. Early and longterm survival of patients operated on for RCC with IVC invasion is negatively influenced by thrombus size, presence of distant metastases, involvement of perirenal fat, lymph nodes and adrenal glands, higher thrombus level and, not least, the experience of the center and surgeons performing the procedure [12–16].

Conclusions

Radical surgery remains the main potentially curative treatment for selected patients with RCC and venous tumor thrombus. The operative strategy should be tailored to the level of

tumor thrombus extension and the extent of IVC wall involvement. Careful preoperative assessment, appropriate patient selection, and multidisciplinary surgical expertise are essential for achieving favorable perioperative outcomes. In experienced centers, radical nephrectomy with tumor thrombus removal and appropriate IVC reconstruction can be performed safely and may provide encouraging mid-term outcomes.

Funding

None declared.

Conflict of Interest

None declared.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

Milanko Makšić: Conceptualization, Supervision, Writing – review & editing.

Tamara Đurić-Kun: Data curation, Investigation, Writing – review & editing.

Vladimir Keča: Data curation, Investigation.

Snježana Miličević: Data curation, Investigation.

Dragan Milošević: Investigation, Methodology.

Aleksandar Košpić: Data curation, Formal analysis, Writing – original draft, Writing – review & editing.

Momir Bobar: Investigation, Methodology, Writing – review & editing.

Lazar B. Davidović: Conceptualization, Supervision.

Ethics Approval and Consent to Participate

Ethical approval for this study was obtained from the Institutional Ethics Committee of the University Clinical Center of the Republic of Srpska. All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments.

Patient Consent Statement

Written informed consent for participation in the study and for publication of anonymized clinical data and images was obtained from all patients included in this case series.

Consent for Publication

Written informed consent for publication of clinical data and images was obtained from all patients included in this case series.

Bibliography

1. Skinner DG., *et al.* "Vena caval involvement by renal cell carcinoma. Surgical resection provides meaningful long-term survival". *Annals of Surgery* 210.3 (1989): 387-394.
2. Stewart JR., *et al.* "Cavoatrial Tumor Thrombectomy Using Cardiopulmonary Bypass Without Circulatory Arrest". *Annals of Thoracic Surgery* 51.5 (1991): 717-722.
3. Suggs WD., *et al.* "Renal cell carcinoma with inferior vena cava involvement". *Journal of Vascular Surgery* 14.3 (1991): 413-418.
4. Nesbitt JC., *et al.* "Surgical Management of Renal Cell Carcinoma with Inferior Vena Cava Tumor Thrombus". *Annals of Thoracic Surgery* 63.6(1997): 1592-1600.
5. Bower TC., *et al.* "Replacement of the inferior vena cava for malignancy: An update". *Journal of Vascular Surgery* 31.2 (2000): 270-281.
6. Bower TC., *et al.* "Vena Cava Replacement for Malignant Disease: Is There a Role?" *Annals of Vascular Surgery* 7.1 (1993): 51-62.
7. Sarmiento JM., *et al.* "Is Combined Partial Hepatectomy with Segmental Resection of Inferior Vena Cava Justified for Malignancy?" *Archives of Surgery* 138.6 (2003): 624-631.
8. Gallucci M., *et al.* "Liver Harvesting Surgical Technique for the Treatment of Retro-Hepatic Caval Thrombosis Concomitant to Renal Cell Carcinoma: Perioperative and Long-Term Results in 15 Patients without Mortality". *European Urology* 45.2 (2004): 194-202.
9. Tang Q., *et al.* "Prognostic outcomes and risk factors for patients with renal cell carcinoma and venous tumor thrombus after radical nephrectomy and thrombectomy: The prognostic significance of venous thrombus level". *BioMed Research International* (2015): 163423.

10. Huguet C., *et al.* "Resection of the Suprarenal Inferior Vena Cava. The Role of Prosthetic Replacement". *Archives of Surgery* 130.7 (1995)793-797.
11. Glowiczki P., *et al.* "Handbook of Venous Disorders". 3rd Edition. Guidelines of American Venous Forum (2009).
12. Lardas M., *et al.* "Systematic Review of Surgical Management of Nonmetastatic Renal Cell Carcinoma with Vena Caval Thrombus". *European Urology* 70.2 (2016): 265-280.
13. Kaplan S., *et al.* "Surgical management of renal cell carcinoma with inferior vena cava tumor thrombus". *American Journal of Surgery* 183.3 (2002): 292-299.
14. Wagner B., *et al.* "Prognostic value of renal vein and inferior vena cava involvement in renal cell carcinoma". *European Urology* 55.2 (2009): 452-460.
15. Martínez-Salamanca JI., *et al.* "Prognostic impact of the 2009 UICC/AJCC TNM staging system for renal cell carcinoma with venous extension". *European Urology* 59.1 (2011): 120-127.
16. Toren P., *et al.* "Results of a national population-based study of outcomes of surgery for renal tumors associated with inferior vena cava thrombus". *Urology* 82.3 (2013): 572-577.