Transabdominal two-cavity approach for radical nephrectomy combined with inferior vena cava thrombectomy for malignant thrombus caused by renal cell carcinoma: a case series

R. Novotny 1, J. Chlupac 1,3, T. Marada 1, V. Borovicka 1, V. Vik 1, L. Voska 4, L. Janousek 1,2 and Jiri Fronek 1,2,3*

Abstract

Background: Advanced renal cell carcinoma in some cases causes malignant intravascular thrombus with the potential for growth into the inferior vena cava or even the right atrium. Renal cell carcinoma is accompanied by malignant intravascular thrombus in up to 10% of cases. We present an overview of three patients diagnosed as having renal cell carcinoma with malignant intravascular thrombus requiring radical nephrectomy combined with inferior vena cava thrombectomy.

Case presentation: Three patients diagnosed as having renal cell carcinoma were indicated for renal cell carcinoma combined with inferior vena cava thrombectomy between 2014 and 2017 at our department: a 69-year-old white Caucasian woman, a 74-year-old white Caucasian woman, and a 58-year-old white Caucasian woman. According to the Novick classification of inferior vena cava tumor thrombus, there was one infrahepatic (level II) and two supradiaphragmatic (level IV) malignant intravascular thrombi. The average age of these patients was 67 years (range 58–74 years). All patients underwent radical nephrectomy combined with inferior vena cava thrombectomy through transabdominal approach. In patients with level IV malignant intravascular thrombus, transesophageal echocardiogram was used to guide the placement of the inferior vena cava cross-clamp above the diaphragm. In one patient the pericardium was opened to place a cross-clamp above a tumor just below the right atrium.

There were no postoperative mortalities to date with an average follow-up of 23 months (range 2–48 months). To date, no patient has demonstrated recurrent inferior vena cava malignant intravascular thrombus requiring secondary inferior vena cava thrombectomy or any other treatment. A comparison of estimated blood loss and transfusion rate was not significantly different in all three cases.

Conclusion: Despite the technical complexity of the procedure, caval thrombectomy combined with radical nephrectomy currently represents the only radical treatment for renal cell carcinoma accompanied by malignant intravascular thrombus with good mid-term oncological outcomes.

Keywords: Renal cell carcinoma, Thrombus, Inferior vena cava, Thrombectomy, Nephrectomy, Transperitoneal
Background
Kidney cancer is the 14th most common cancer worldwide [1]. Renal cell carcinoma (RCC) accounts for 90 to 95% of malignant neoplasms arising from the kidney. The incidence of RCC differs greatly between regions, with the highest rates observed in the Czech Republic and North America [2]. Advanced RCC is in some cases accompanied by a malignant renal vein thrombus with potential to grow into the inferior vena cava (IVC) or even the right atrium (RA) [3]. RCC is accompanied by an intravascular malignant thrombus in up to 10% of cases [4]. This is considered to be a detrimental prognostic parameter reducing the patients’ 5-year cancer-specific survival by 17–36% [5, 6]. Surgical resection of the RCC combined with IVC thrombus removal has become the primary treatment option, with postoperative 5-year survival rate without metastasis ranging from 45–69% [7].

Case presentation
Patients
All patients were examined, diagnosed, and evaluated by a multidisciplinary team. Patients’ preoperative computed tomography and magnetic resonance images are summarized in Fig. 1. After a thorough discussion of the indications, and risks and benefits of the procedure, patients were approved for the procedure. All of the patients’ hospital stays are summarized in Table 1.

Surgical procedure
All of the procedures were performed under full anesthesia. A midline laparotomy was performed in all of the patients without the differentiation of the left-sided or right-sided RCC. After the nephrectomy was performed, the IVC was dissected in a standard manner. The midline laparotomy allowed for an easy mobilization of the liver in patients where IVC cross-clamp had to be placed above the liver. In patients with a supradiaphragmatic malignant tumorous thrombus, a two-cavity (abdomen-thorax) procedure through a midline laparotomy was performed. The cross-clamp was placed above the diaphragm or just below the RA without the need for a sternotomy. We used either supradiaphragmatic or subxiphoid access for the cross-clamp placement. In these cases, a transesophageal echocardiogram (TEE) was used to monitor the positioning of the IVC cross-clamp to the thrombus localization.

Patients follow-up
Every patient underwent an ultrasonographic check-up at 2-month and 6-month intervals after the procedure, followed by an annual ultrasonographic check-up.

Results
Patient 1
A 69-year-old white Caucasian woman with right kidney tumor and IVC supradiaphragmatic thrombus with no relevant medical history was referred to our department for treatment. Based on computed tomography angiography (CTAG) the tumor was classified as level IV (Fig. 1). The results of a laboratory evaluation before the procedure were: hemoglobin (Hb) 92 g/L, C-reactive protein (CRP) 63.9 mg/L, urea 4.6 mmol/L, creatinine 88.5 μmol/L, and white blood cells (WBC) 10.2 × 10^9/L.

A right nephrectomy was performed in a standard manner with a tumor of the size 40 × 37 × 35mm (Fig. 2). TEE was used to determine the position of the IVC clamp with reference to the tumor position. Based on TEE, the pericardium was resected, and an IVC clamp was placed just below the RA through subxiphoid access. A cavotomy was performed with the extraction of tumor thrombus 85 × 35 mm. The cavotomy and laparotomy were closed in a standard manner using non-absorbable monofilament running suture.

She was discharged on the 11th postoperative day with urea 5.6 mmol/L and creatinine 67.8 μmol/L. Her postoperative period was uneventful. Tumor histology...
| Patient number | Sex   | Age | Renal functions before surgery | Preoperative CRP (mg/L) | Renal functions after surgery | Supradiaphragmatic access used | Pericardial resection | Inferior vena cava resection | Histology (Fuhrman classification) | Hospital stay (days) | Follow-up (months) |
|----------------|-------|-----|---------------------------------|-------------------------|-----------------------------|------------------------------|----------------------|-----------------------------|---------------------------------|---------------------|----------------------|
| 1              | Female| 69  | 4.6                             | 88.5                    | 63.9                        | 5.6                          | 6.8                  | No                          | Clear cell renal carcinoma Patient 1 - pT3b pNO pMO, grade 3/4 | 11                  | 2                    |
| 2              | Female| 74  | 4.8                             | 98.7                    | 35                          | 10                           | 129.7                | Yes                         | Clear cell renal carcinoma Patient 2 - pT3b pNO pMO, grade 4 | 8                  | 18                   |
| 3              | Female| 58  | 5                               | 105.4                   | 522                         | 9.2                          | 111.2                | No                          | Clear cell renal carcinoma Patient 3 - pT3a pNO, pMO, grade 3 | 6                  | 48                   |

CRP: C-reactive protein
revealed clear cell renal carcinoma Patient 1 - pT3b pNO pMO, grade 3/4 (Fuhrman classification) (Fig. 3). She is alive without recurrence of RCC and/or IVC tumor thrombus at a 2-month follow-up.

**Patient 2**
A 74-year-old white Caucasian woman with left kidney tumor and supradiaphragmatic IVC malignant thrombus reaching the RA with no relevant medical history was referred to our department for treatment. Based on CTAG the tumor was classified as level IV (Fig. 1). The results of a laboratory evaluation before the procedure were: Hb 92 g/L, CRP 35 mg/L, urea 4.8 mmol/L, creatinine 98.7 μmol/L, and WBC 10.6 × 10⁹/L.

Her left kidney and IVC were dissected, liver mobilized. Atrial thrombus was confirmed using TEE. First, a nephrectomy of the left kidney was performed in a standard manner. The tumor size was 75 × 80 × 72 mm. Based on the TEE the thrombus in the RA was hardly attached to its wall. A transdiaphragmatic approach was used. A circular suture was placed on the RA where the thrombus was attached, the RA was opened, and the thrombus was flushed out. The RA was closed with primary suture. TEE confirmed the removal of the entire thrombus; therefore, there was no need to remove the thrombus with the use of extracorporeal circulation. In the end, a cavotomy was performed, and the malignant thrombus was removed. The cavotomy closure was performed with primary suture.

On the 8th postoperative day, our patient was transferred to the department of internal medicine for further treatment with urea 10 mmol/L and creatinine 129.7 μmol/L. Tumor histology revealed clear cell renal carcinoma Patient 2 - pT3b pNO pMO, grade 4 (Fuhrman classification) (Fig. 3). She is alive and was without recurrence of RCC and/or IVC tumor thrombus at an 18-month follow-up.

**Patient 3**
A 58-year-old white Caucasian woman with right kidney tumor and IVC thrombus with no relevant medical history was referred to our department for treatment. Based on CTAG the tumor was classified as level II (Fig. 1). The results of a laboratory evaluation before the procedure were: Hb 83 g/L, CRP 52.2 mg/L, urea 5 mmol/L, creatinine 105.4 μmol/L, and WBC 12.2 × 10⁹/L.

The right kidney and IVC were dissected in a standard manner. IVC was dilated up to 5 cm just under the right ventricle (RV). A right nephrectomy was performed in a standard manner. The tumor dimensions were 120 × 75 × 70 mm. An IVC cross-clamp was placed just under the liver. The tumorous thrombus was removed through cavotomy in two pieces (65 × 40 × 40 mm and 42 × 30 × 32 mm).
prognostic marker in patients without metastases [4, 16].

III–level I

et al. by Weiss survival in patients with RCC was extensively assessed consistency of a thrombus impact on a cancer-specific thera monitoring or eventual oncologic treatment. The marker that would screen the patients in need for fur-

there is a high insistence on determining a prognostic 

there is no commonly used standardized classification. They grouped intrahepatic and retrohe-
et al. et et al. that their surgical approach greatly differs. To this day, patic IVC thrombi in the same category despite the fact major drawback. They grouped intrahepatic and retrohe-

Discussion

Advanced RCC with IVC thrombus has an unfavorable prognosis. Even in cases where no metastasis is revealed it is accompanied by cancer-specific death in 29% of cases [8, 9]. Surgical resection of IVC tumor thrombus prolongs a patient’s survival rate. A study by Tang et al. demonstrated that nephrectomy combined with IVC tumor thrombus resection had achieved a 62.9% survival in 5 years and 56% in 10 years [8]. The surgical strategy for IVC tumor thrombus resection depends on the level of the thrombus extension. The most complex surgical strategy is usually required for patients with level IV thrombus. These technically challenging procedures are accompanied by 30% morbidity and 15% mortality with frequently used extracorporeal circulation and hypothermic circulatory arrest in order to create optimal conditions for tumor extirpation [10]. RCC with IVC tumor thrombus is classified based on the thrombus level and its relationship to the hepatic venous system. This is important for the determination of the safest and most effective method for the surgical procedure. The first classification was introduced by Libertino in 1986, followed by Wilkinson et al. and Pritchett et al. [3, 11–13]. These classifications had a major drawback. They grouped intrahepatic and retrohe-

Our novel surgical approach allows us to perform radical nephrectomy combined with IVC thrombectomy especially in patients with supradiaphragmatic thrombus through a single incision, upper midline laparotomy. Our surgical strategy eliminates the need for full or partial sternotomy, and thoracotomy in patients with supradiaphragmatic thrombus where extracorporeal circulation is not needed. We combine either transdiaphragmatic or subxi-

Conclusions

Patients with advanced RCC have a low survival rate without surgical intervention. Despite the technical complexity of the procedure, caval thrombectomy combined with radical nephrectomy currently represents the only radical treatment of RCC accompanied by a malignant thrombus in the IVC. Our novel surgical approach through a mid-

Acknowledgements

The author would like to thank Doc. MUDr. Jiri Fronek PhD FRCS, Transplant Surgery Department, Institute for Clinical and Experimental Medicine, Prague, Czech Republic for intraoperative pictures and critical reviews on this report.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Authors’ contributions

RN manuscript preparation, manuscript draft, design of case series. JC manuscript draft, design of the case series. TM data collection. VV data collection. VB data collection, data analysis. LV histological analysis, histological pictures. LJ coordination of the study. JF overview, manuscript approval. All authors read and approved the final manuscript.

Ethics approval and consent to participate

This study does not require ethical committee approval.
Consent for publication
Written informed consent was obtained from all of the patients for publication of this manuscript and accompanying images. A copy of the written consents is available for review by the Editor-in-Chief of this journal.

Competing interests
The authors declare that they have no competing interests regarding the publication of this article.

Publisher’s Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details
1 Transplant Surgery Department, Institute for Clinical and Experimental Medicine, Videnska 1958/9, 14021 Prague, Czech Republic. 2 First Faculty of Medicine, Charles University, Prague, Czech Republic. 3 Second Faculty of Medicine, Charles University, Prague, Czech Republic. 4 Department of Pathology, Institute for Clinical and Experimental Medicine, Prague, Czech Republic.

Received: 17 May 2018 Accepted: 9 September 2018

Published online: 25 October 2018

References
1. Ridge CA, Pua BB, Madoff DC. Epidemiology and Staging of Renal Cell Carcinoma. Semin Intervent Radiol. 2014;31(1):3–8. https://doi.org/10.1055/s-0033-1363887.
2. Chow WH, Dong LM, Devesa SS. Epidemiology and risk factors for kidney cancer. Nat Rev Urol. 2010;7(5):245–57. https://doi.org/10.1038/nrurol.2010.46.
3. Mandhani A, Patidar N, Aga P, Pande S, Tewari P. A new classification of inferior vena cava thrombus in renal cell carcinoma could define the need for cardiopulmonary or venovenous bypass. Indian J Urol. 2015;31(4):327–32. https://doi.org/10.4103/0970-1591.164459.
4. Mager R, Daneshmand S, Evans CP, Palou J, Martinez-Salamanca JI, Master VA, et al. Renal cell carcinoma with inferior vena cava involvement: Prognostic effect of Tumor thrombus consistency on cancer-specific survival. J Surg Oncol. 2016;114(6):764–8. https://doi.org/10.1002/jso.24395.
5. Zisman A, Wieder JA, Pantuck AJ, et al. Renal cell carcinoma with tumour thrombus extension: biology, role of nephrectomy and response to immunotherapy. J Urol. 2003;169:909–16.
6. Tilli D, Hu B, Nguyen HC, et al. Impact of synchronous metastasis distribution on cancer-specific survival in renal cell carcinoma after radical nephrectomy with tumour thrombectomy. J Urol. 2015;193:436–42.
7. Toren P, Aboouassaly R, Timilshina N, Kulkarni G, Alibhai S, Finelli A. Results of a national population-based study of outcomes of surgery for renal tumors associated with inferior vena cava thrombosis. Urology. 2013;82(3):574–7. https://doi.org/10.1016/j.urology.2013.04.054.
8. Tang Q, Song Y, Li X, Meng M, Zhang Q, Wang J, 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 Tumor Thrombus Level. Biomed Res Int. 2015;2015:163423. https://doi.org/10.1155/2015/163423. Epub 2015 Sep 3.
9. Heng DY, Wells JC, Rini BI, et al. Cytoreductive nephrectomy in patients with synchronous metastases from renal cell carcinoma: results from the International Metastatic Renal Cell Carcinoma Database Consortium. Eur Urol. 2014;66:704–10.
10. Palma-Zamora I, Dalea D, Barod R, Hsu L, Monen M, Rogers CG. Initial robotic assistance in the surgical management of renal cell carcinoma with level 4 caval thrombus. J Robot Surg. 2017; https://doi.org/10.1007/s11701-017-0766-1.
11. Libertino JA. Renal cell cancer with extension into vena cava. In: McDougal WS, editor. Rob & Smith’s Operative Surgery: Urology. 4th ed. London: Butterworth & Co.; 1986. p. 127.
12. Belis JA, Pae WE Jr, Rohner TJ Jr, et al. Cardiovascular evaluation before circulatory arrest for removal of vena caval extension of renal carcinoma. J Urol. 1989;141(6):1302–7.
13. Stief CG, Schäfers HJ, Kuczyk M, et al. Renal-cell carcinoma with intracaval neoplastic extension: Stratification and surgical technique. World J Urol. 1995;13(3):166–70.
14. Weiss VL, Braun M, Perner S, et al. Prognostic significance of venous tumour thrombus consistency in patients with renal cell carcinoma (RCC). BJU Int. 2014;113:209–17.
15. Antonelli A, Sodano M, Sandri M, et al. Venous tumour thrombus consistency is not predictive of survival in patients with renal cell carcinoma: A retrospective study of 147 patients. Int J Urol. 2015;22:534–9.
16. Tilli D, Nguyen HG, Dall’Era MA, et al. Impact of histologic subtype on cancer-specific survival in patients with renal cell carcinoma and tumour thrombus. Eur Urol. 2014;66:577–83.
17. Ihaddadene R, Yokom DW, Le Gal G, Moretto P, Canil CM, Dellac A, et al. The risk of venous thromboembolism in renal cell carcinoma patients with residual tumor thrombus. J Thromb Haemost. 2014;12(6):855–9. https://doi.org/10.1111/jth.12580.
18. Lee AY, Levine MN, Baker RI, Bowden C, Kakkar AK, Prins M, et al. Low-molecular-weight heparin versus a coumarin for the prevention of recurrent venous thromboembolism in patients with cancer. N Engl J Med. 2003;349(2):146–53.

Ready to submit your research? Choose BMC and benefit from:
- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions