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Surgery in Motion

Results of Endoluminal Occlusion of the Inferior Vena Cava During Radical Nephrectomy and Thrombectomy

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Abstract

Background: The surgical management of renal tumours with thrombi in the inferior vena cava (IVC) has become the gold standard treatment.
Objective: To evaluate endoluminal occlusion of the IVC during radical nephrectomy with either retrohepatic (level II) or suprahepatic (level III) caval tumour thrombus.
Design, setting, and participants: From January 2000 to October 2007, 28 consecutive patients with renal cell carcinoma presenting a thrombus level II or III were treated with endoluminal occlusion of the free IVC cranial.
Surgical procedure: The occlusion balloon was positioned under transesophageal echography (TEE) control through a cavotomy performed at the level of the renal vein ostium. Thrombectomy and radical nephrectomy were then performed.
Measurements: Operative time, perioperative bleeding, and pre- and postoperative complications were assessed. Overall patient survival time, disease-free survival, and development of metastasis were assessed.
Results and limitations: Caval thrombectomy was performed successfully in all patients. IVC replacement with an expanded polytetrafluoroethylene graft or patch closure after lateral cavectomy was performed in 10 and 4 patients, respectively. Average operative time was 160 min (range: 120–210). There was no perioperative mortality. The complications were one splenectomy and one early thrombosis of the IVC. Mean length of follow-up was 22.1 mo (range: 3–90). There was no local or IVC tumour recurrence. Cause-specific death and metastasis occurred in six (21.4%) and nine patients (32.1%), respectively. Thirteen patients (46.4%) are disease-free.
Conclusions: Endoluminal occlusion of the IVC with TEE monitoring for level II and III thrombus avoided a suprahepatic or subdiaphragmatic approach of the IVC. Segmental resection and reconstruction of the IVC could also be performed in case of adherent thrombi.
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1. Introduction

Renal cell carcinoma (RCC) is the most common type of tumour occupying or extending into the inferior vena cava (IVC). Tumour extension and invasion of the IVC is observed in 4 to 19% of RCCs [1,2].

The presence of a tumour thrombus in the IVC associated with a renal carcinoma does not modify survival when total excision of the thrombus is performed and in the absence of nodal or visceral metastases [3–5]. In 1913, Berg reported the first nephrectomy with caval thrombectomy in the setting of a renal clear-cell carcinoma extending into the IVC [6]. Since then, the surgical management of renal tumours with thrombi in the IVC has become the gold standard treatment, with reported perioperative mortality rates ranging from 2.7 to 13% [2,7,8]. Survival at 5 yr for patients operated on without preoperative metastases varies between 30 and 72% [2,8–10]. These results are comparable with the prognosis of patients with a renal tumour only invading the renal vein [10,11]. The short- and mid-term major complications of IVC tumour thrombi are massive pulmonary embolism, total obstruction of the tricuspid valve, and liver failure following a Budd-Chiari syndrome, justifying surgical intervention [12]. The surgical strategy is adapted to the cephalic extent of the thrombus and to the presence of IVC wall tumour invasion. These can be assessed preoperatively by computed tomography (CT) angiography scan, magnetic resonance imaging (MRI), and transesophageal echography (TEE). In our study, we assessed the endoluminal occlusion of the IVC cranial to the thrombus. This technique allowed us to remove the thrombus through a cavotomy at the level of the renal vein ostium, thus eliminating the need for liver mobilization and transdiaphragmatic or sternotomy approach of the IVC. We describe and evaluate this technique.

2. Methods and patients

From January 2000 to October 2007, 63 patients with renal vein/inferior vena caval involvement (T3b/c), out of 440 patients who underwent radical nephrectomy, were selected for review. Of these patients, 28 consecutive patients (14 females and 14 males) with renal cell carcinoma presenting a thrombus that was either retrohepatic (level II) or suprahepatic (level III) were treated with endoluminal occlusion of the free IVC cranial to the thrombus. Surgery was performed by urological and vascular surgeons.

The staging evaluation included CT scan of the thorax, abdomen, and pelvis; abdominal ultrasound associated with color Doppler; and magnetic resonance imaging (MRI) angiography in all patients. MRI was performed within 3 d before surgery in order to be sure that the upper extent of the thrombus had not reached the right atrium and that the patient could be managed without cardiopulmonary bypass and sternotomy. The location of the upper extent of the tumour thrombus was defined in accordance with the four levels described by Neves and Zincke [13]: level I (or renal): the tumour thrombus is located less than 2 cm above the ostium of the renal vein in the IVC; level II (or retrohepatic): the head of the thrombus is located below the main hepatic veins; level III (or suprahepatic): the thrombus is located above the main hepatic veins; and level IV (or atrial): the thrombus is in the right atrium. Locoregional and metastatic extension were evaluated in every patient by brain and chest CT scan, bone scan, and hepatic ultrasound.

2.1. *Surgical technique*

The surgical technique was previously described [14] and was as follows: At the beginning of the procedure, a TEE was

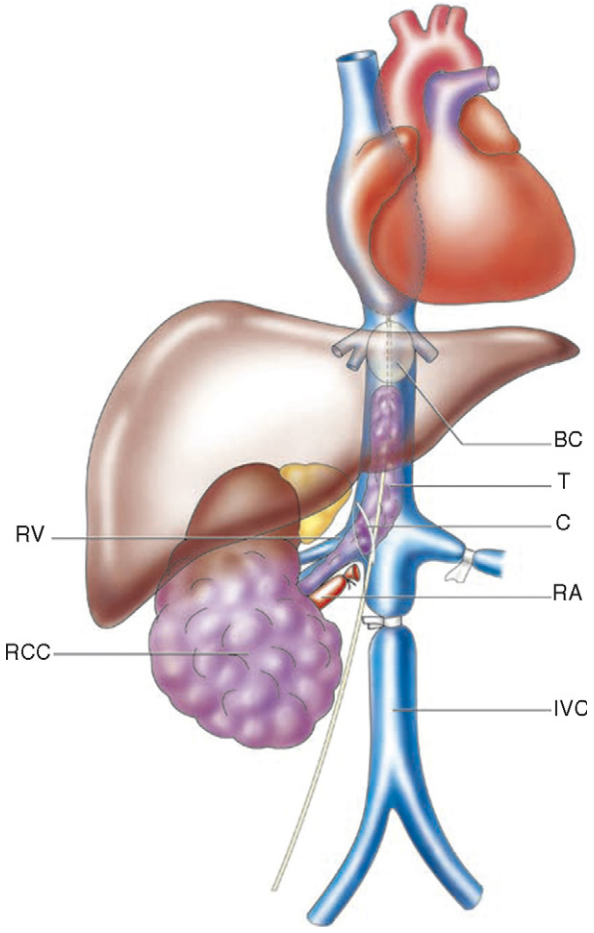

Fig. 1 – Right renal cell carcinoma (RCC) with inferior vena cava (IVC) thrombus (T). Infrahepatic approach to control a retrohepatic IVC thrombi. Division of renal artery (RA). Contralateral renal vein and infrarenal IVC blood flow controlled with Rummel tourniquets. A short cavotomy (C) at the level of the renal vein (RV) allowed endoluminal occlusion of the IVC with a balloon catheter (BC) placed distal to the thrombi under transesophageal echocardiography. Thrombectomy and radical nephrectomy were then performed.

performed to determine the upper level of the thrombus. TEE was performed throughout the procedure to localize the occlusive balloon in the free segment of the IVC, to monitor air or tumour embolisms, and to check that the thrombus had been completely removed. To control the retrohepatic and suprahepatic thrombi, the IVC was exposed at the level of the renal veins and in its infrahepatic segment, whatever the side of the primitive tumour. The renal artery was ligated. The infrarenal IVC and the contralateral renal vein were clamped using Rummel tourniquets. A short cavotomy was performed at the ostium of the renal vein. An occlusion catheter (venous catheter, size 8/22F, 80 cm long, maximum volume 43 cc, Syntel, Applied Medical, Nieuwegein, Netherlands) was introduced in the cavotomy up to the free segment of the IVC localized by TEE. The balloon catheter was then inflated with physiological saline solution, thus performing endoluminal occlusion of the free IVC above the thrombus (Fig. 1). The balloon volume was adjusted to the caval diameter assessed by real-time TEE. The thrombus was removed en bloc through a large, longitudinal anterolateral cavotomy, either by direct extraction or by stripping with a second balloon. In the setting of a level III thrombus, hepatic backflow was controlled only immediately after the thrombus had been removed by repositioning the inflated balloon below the hepatic veins under TEE control. When the lumen of the vena cava presented a normal diameter, the cavotomy was closed with a non-absorbable 5.0 monofilament polypropylene direct double-running suture. In the other cases, the cavotomy was closed on a polytetrafluoroethylene (PTFE) prosthetic patch. If there was macroscopic or MRI evidence of invasion of the IVC wall, a segmental cavectomy was performed. In these cases, a 19-mm–diameter expanded PTFE graft prosthesis was implanted. In this setting, the contralateral renal vein was laterally anastomosed to the PTFE graft. Radical nephrectomy was then performed. Angio-CT scan of the thorax and abdomen was performed on postoperative day 10 to verify IVC patency and the absence of pulmonary embolism. Follow-up (serum creatininemia and thoracoabdominal CT scan) was performed every 6 mo during the first 3 yr and yearly thereafter.

All tumours were classified according to the 2002 TNM classifications [15].

Operative time was measured from skin incision to skin closure. Perioperative bleeding was quantified by the number of packed red cells transfused during the perioperative period. Postoperative complications were assessed.

Overall patient survival time was calculated from the date of surgery to date of death or last follow-up visit. Disease-free survival and development of metastasis were assessed.

3. Results

The upper extent of the thrombus was retrohepatic and suprahepatic in 18 and 10 patients, respectively. There was no difference between the upper extent of the caval thrombus assessed by the preoperative MRI and the perioperative TEE. Clinical and pathologic characteristics of the study population are described in Table 1.

Table 1 – Clinical and pathologic characteristics of study population

Characteristics	N (%)
N	28
Mean age (range, years)	59.9 (20–79)
Gender (female)	14 (50)
ECOG	
0	18 (64.3)
1	10 (35.7)
BMI (range, kg/m^2)	26.5 (19.7–46.9)
Asymptomatic	5 (17.8)
Laterality (left)	14 (50)
Thrombus level	
Retrohepatic (level II)	18 (64.3)
Suprahepatic (level III)	10 (35.7)
pT stage	
pT3b	26 (92.9)
pT4	2 (7.1)
N stage	
N0	25 (89.3)
N1	3 (10.7)
M1	7 (25)
Pathology	
Clear cell RCC	23 (82.1)
Papillary (subtype 2)	2 (7.1)
Collecting duct carcinoma	2 (7.1)
Adult nephroblastoma	1 (3.6)
Fuhrman grade	
III	13 (46.4)
IV	15 (53.6)

Thrombectomy with endoluminal occlusion of the IVC was performed without any dissection of the retrohepatic and supradiaphragmatic IVC in all cases. A lateral cavectomy around the renal vein orifice of the tumoral kidney was performed in 25:28 patients (89.3%). The cavectomy was closed by direct suture or, if required, a prosthetic patch in 14 (50%) and 4 patients (30%), respectively. Gross invasion of the IVC wall by the tumour required a segmental cavectomy replaced by a PTFE graft in 10 patients (35.7%). No drop in blood pressure resulted from the IVC endoluminal occlusion. No Pringle manoeuvre (clamping of the hepatic pedicle), cardiopulmonary bypass, or venovenous bypass was performed. The mean operative time was 160 min (range: 120–210 min).

The angio-CT-scan control showed a patent IVC in 27 patients (94.4%). A thrombosed IVC was diagnosed in one patient. This latter patient had undergone a cavectomy around the ostium of the renal vein with direct suture of the IVC; the thrombosed IVC was secondary to a retroperitoneal hematoma. This patient remained symptom-free. No kidney failure or cardiorespiratory complications were observed. The average number of packed red

cells transfused was 5 (range: 0–16). The patients were discharged from the intensive care unit on average 3 d (range: 1–11) after surgery. Average time to hospital discharge was 10 d (range: 7–28). No death occurred in the perioperative period.

Total resection (R0) of the primary tumour was performed in 24 patients, and 4 patients had macroscopic positive margins (R2) after surgical excision at the level of regional lymphatic tissue. The Fuhrman grade was high (III or IV) in all cases. The IVC wall was invaded by the tumour thrombus at the level of the ostium of the renal vein in 14 cases (50%), and pathology indicated negative surgical margins.

Mean length of follow-up was 22.1 mo (range: 3–90). IVC PTFE bypass or patch were still patent. There was no local or IVC tumour recurrence. Cause-specific death and metastasis occurred in 6 (21.4%) and 9 patients (32.1%), respectively. Thirteen patients (46.4%) were disease-free. Mean disease-free survival was 10.3 mo (range: 2–38).

4. Discussion

We successfully performed an endoluminal occlusion of the free IVC above the thrombus. This technique did not lead to any major complications and was safe under TEE monitoring. This technique also allowed us to perform a segmental resection and reconstruction of the IVC when tumour invasion of the IVC wall was noted. No drop in blood pressure occurred during the occlusion. We recommend this technique for renal cell carcinomas with level III retro- and suprahepatic IVC thrombus, except if an IVC wall invasion above the hepatic veins is depicted on the preoperative MRI or by TEE monitoring. In that setting, dissection and mobilization of the liver, associated with a cardiopulmonary bypass, should be performed. However, this extremely rare situation was not encountered in our series.

Most authors report an intrapericardial or retrohepatic approach of the IVC for level II or III thrombi, either by sternotomy, transdiaphragmatic approach, or liver mobilization [16–18]. Compared to the outcomes from published series, the advantages of our strategy are lower risk of tumour embolism, lower risk of transfusions, lower pulmonary complications, and shortened operative time. Specifically, liver mobilization or transdiaphragmatic approach to the IVC distal to the thrombus does not eliminate the risk of perioperative embolism. Tomita et al, using perioperative TEE monitoring, reported an increased risk of thrombus migration during liver mobilization [19]. Pre- and perioperative parameters evaluated in our series demonstrated favourable outcomes compared to other series. Perioperative bleeding (5 packed red cells transfused on average in our study) was lower compared to the Nesbitt et al [2] series (7.2 packed red cells transfused on average in 19 level II or III patients). Ciancio et al [20] reported a lower number of transfusions (0 to 4 packed red cells) when liver mobilization was performed in 23 level III patients, but did not monitor the appearance of perioperative embolism with TEE. Gallucci et al [18] reported 10 cases of thrombectomy performed with liver mobilization for level II or III thrombi. No fragmentation of the thrombi was observed, but there was no perioperative TEE. Average operative time in other series ranged between 240 and 342 min [18,20] versus an average operative time of 160 min in our experience.

IVC wall invasion is frequently located around the renal vein orifice [1]. In our series, the IVC wall was invaded at pathologic examination in 14 cases (50%). Preoperative imaging measurements of IVC and RV ostium diameters can accurately predict invasion of the RV ostium wall [21]. Segmental cavectomy and PTFE replacement in this setting prevent IVC thrombus recurrence.

Our experience corroborates previous reports validating nephrectomy with thrombectomy of the IVC as a procedure that can be performed without cardiopulmonary bypass (CPB), except in the setting of intracardiac thrombi (level IV) [2,22]. However, other authors recommend using CPB, with or without hypothermia and cardiac arrest, for level III and IV thrombus to ensure hemodynamic stability during IVC clamping and a bloodless field [10,23–25]. Actually, CPB increases the operative time, cardiorespiratory complications, postoperative bleeding, and the onset of coagulopathies [2,18]. Clamping of the subrenal aorta to avoid CPB and maintain arterial blood pressure was also described, but one patient died from perioperative embolism with this technique [1]. Cianco et al reported a complete piggyback liver mobilization and milking the thrombus below the hepatic veins for 7 patients with tumour thrombus extending above the diaphragm. One patient died on postoperative day 4 of cardiac arrest due to an arrhythmia [26].

We add our experience with removal of IVC tumour thrombi without bypass techniques or liver mobilization because the outcome is at least comparable, with lower morbidity and mortality. Coagulopathy was a rare event in our patients, and no neurologic sequelae resulted. Pulmonary complications, chest tube drainage, and sternotomy dehiscence were avoided.

Two-dimensional perioperative TEE is a noninvasive technique providing both the surgeon and the anaesthesiologist with significant information [27]. It confirms the exact position of the thrombus according to the preoperative work-up. In our study, there was no difference between the pre- and perioperative extent of the thrombi. TEE is used to detect tumour and air embolisms, to depict the endoluminal occlusive balloon position in the free IVC above the thrombus, and to verify that the thrombus has been completely removed. TEE never depicted air or tumour embolism when the balloon catheter was advanced in the IVC at the level of the thrombus. One might discuss the placement of the balloon catheter in an antegrade approach through a jugular or subclavian route to avoid this risk of tumour embolism. However, we did not use this approach because the balloon catheter could be displaced in the right atrium during the surgery, and it would be difficult to replace it rapidly in the IVC. Furthermore, it may be difficult to place the balloon catheter below the subhepatic veins as soon as the thrombus is removed to decrease hepatic ischemia and blood loss. Vascular surgeons are more familiar with retrograde approaches for IVC surgery. The accuracy of TEE for intracardiac masses was debated by Gulati et al [28], but for IVC thrombus analysis, the accuracy is very reliable [29]. TEE is also efficient for anaesthetic monitoring. It can replace a Swan-Ganz pulmonary arterial catheter, monitor ventricular function and mobility of the cardiac wall and septum, and study the cardiac valves.

The limitations of this technique are as follows: A circumferential wall IVC invasion or a bulky thrombus that completely fills the IVC lumen could stop the balloon progression to the free IVC segment. The preoperative work-up must assess this situation, and a sternotomy or a transdiaphragmatic approach with liver mobilization could be scheduled to perform the thrombectomy. Retrohepatic IVC wall invasion is also a rare event, and MRI could underestimate this IVC wall invasion. IVC replacement must be performed in such a case, with a Pringle manoeuvre and a liver mobilization to clamp the IVC above the hepatic veins [17,18].

5. Conclusions

In our experience, endoluminal occlusion of the IVC with TEE monitoring for retrohepatic and suprahepatic thrombus avoided sternotomy or transdiaphragmatic approach of the suprahepatic and supradiaphragmatic IVC. Successful thrombectomy was performed in all cases. A segmental resection and reconstruction of the IVC was allowed if IVC wall invasion occurred. This technique was not associated with any major complications and was very reliable. Systematic TEE monitoring is necessary.

Author contributions: Laurent Zini had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Zini, Koussa.
Acquisition of data: Zini.
Analysis and interpretation of data: Zini, Koussa.
Drafting of the manuscript: Zini, Haulon.
Critical revision of the manuscript for important intellectual content: Villers.
Statistical analysis: None.
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Supervision: Villers, Biserte, Decoene.
Other (specify): None.

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Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found, in the online version, at doi:10.1016/j.eururo.2008.05.016 and via www.europeanurology.com. Subscribers to the printed journal will find the Surgery in Motion DVD enclosed.

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Editorial Comment on: Results of Endoluminal Occlusion of the Inferior Vena Cava During Radical Nephrectomy and Thrombectomy

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Surgery for renal cell carcinoma with venous thrombus in the inferior vena cava (IVC) is a major challenge for the urologist. Knowing that surgery is still the most effective therapy whenever possible, every attempt has to be made to remove the thrombus in the IVC. This procedure will not only improve the survival rate of the patient but will

also provide a better quality of life [1]. In this issue of *European Urology*, Zini et al describe their technique and results in their "Surgery in Motion" article [2]. They used their technique in 28 patients with levels II and III thrombus and state that the technique is very reliable and free of complications. The authors claim that the technique shortens the operative time and that there is lower risk of embolism, transfusions, and pulmonary complications. They performed the operation with transesophagial ultrasonography monitoring.

It is quite understandable that each and every surgeon has a different approach to the particular problem. One of the major complications during this type of surgery is the tumor embolism. I always try not to manipulate the IVC. The first thing I want to achieve is the safe control of the IVC above the thrombus. In this respect, hepatic mobilization can be very useful [3]. It is true that it may take longer than just sending in a balloon catheter, but it seems safer to me. I am always concerned that the catheter may tear a small piece of tumor from the thrombus and that the piece may go into the circulation. This problem can occur particularly when the tumor thrombus fills the lumen of the IVC. As the authors state in their manuscript, if there is adherence of the thrombus to the IVC wall, then tearing may be even more likely. I find no imaging technique to clearly demonstrate the caval wall invasion.

Every new technique will have new users, and only time will tell which technique is safer and more effective in achieving our goal. The authors should be congratulated for adding another approach to our armamentarium to deal with this important problem, and I look forward to watching their video.

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