Renal tumours with cavo-atrial extension: surgical management and outcome

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Abstract

Surgery is the most effective treatment for the management of patients with renal cell carcinoma (RCC) and involvement of inferior vena cava (IVC). Data were accrued for 68 consecutive patients, who underwent surgical resection for RCC with IVC extension and required cardiothoracic surgical input from May 1993 to May 2005. The mean age of patients was 60.7 years (range 25–84, S.D. 11.6 years), 49 of these were males. The majority required application of vascular clamp at the junction of IVC with right atrium (RA), however, 21 patients required cardiopulmonary bypass (CPB) (29–193 min, mean 131 min). Hypothermic circulatory arrest (HCA) (12–42 min, mean 26 min) was used in 17 patients. The 30-day mortality was 6% (four patients) with no death in the elective CPB group. At a mean follow-up of 31 months, the overall two- and five-year survival rates were 50% and 37%, respectively. Cox regression revealed presence of metastasis (Odds ratio (OR) 3.1, 95% CI 1.2–8.2) and age > 70 years (OR 2.9, 95% CI 1.3–6.3) adversely affected the long-term outcome. The management of RCC with IVC involvement is evolving for this complex group of patients. A multidisciplinary approach in selected patients is associated with good short- and long-term results.

Keywords: Renal cell carcinoma; Cavol extension; Cardiopulmonary bypass; Hypothermia

1. Introduction

Renal cell carcinoma (RCC) is a common urological tumour, representing 1–3% of all visceral cancers and 85–90% of all malignant kidney tumours. The extension of tumour thrombus into the inferior vena cava (IVC) in renal cell carcinoma is a relatively uncommon event occurring in 4–25% of all cases [1]. Approximately 2–10% of these patients have tumour thrombus extending into the RA [1–3]. The presence of tumour thrombus in the IVC has not been shown to be determinant of survival, when treated surgically. Surgery is the cornerstone of therapy in these patients, as conventional chemo-radiotherapy alone is not useful. Multiple reports over the past few years have documented clear superiority of surgery over other treatments [3–5]. Improvements in imaging modalities, introduction of dynamic monitoring by transoesophageal echocardiography and the adoption of bypass techniques including CPB and HCA have improved the safety and completeness of these challenging procedures [6].

2. Material and methods

From May 1993 to May 2005, 396 patients underwent radical nephrectomy for RCC at Queen Elizabeth Hospital, Birmingham. Sixty-eight patients (17%) had RCC and IVC extension. There were 49 males with a mean age of 60.7 years (range 25–84 years). On presentation, 71% patients had gross or microscopic haematuria, 68% had flank pain and 49% had a palpable abdominal mass. Twenty-two percent of patients had features suggestive of IVC obstruction.

The renal tumour with its extension was assessed by ultrasonography and computerised tomography. All patients with IVC extension had transthoracic echocardiogram to examine intracardiac extension of tumour thrombus and assess myocardial function (Fig. 1). More recently, in patients predicted to require CPB, coronary angiography was also performed.

The level of tumour thrombus is classified as in Table 1 [2].

All patients underwent radical nephrectomy and complete removal of IVC tumour thrombus. The choice of surgical approach was dependent on the classification based on cephalad extent of the tumour thrombus.
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Fig. 1. Transoesophageal echocardiogram and CT-scan demonstrating tumour thrombus in RA straddling the tricuspid valve.

Table 1

<table>
<thead>
<tr>
<th>Level</th>
<th>Position of tumour thrombus</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>~2 cm above the renal vein</td>
</tr>
<tr>
<td>2</td>
<td>&gt;2 cm above the renal vein, but below the hepatic veins</td>
</tr>
<tr>
<td>3</td>
<td>At level of or above the hepatic veins but below the diaphragm</td>
</tr>
<tr>
<td>4</td>
<td>Above the diaphragm</td>
</tr>
<tr>
<td>4a</td>
<td>Level of eustachian valve, not entering the right atrium</td>
</tr>
<tr>
<td>4b</td>
<td>In the RA</td>
</tr>
<tr>
<td>4c</td>
<td>Extending across the atrioventricular valve</td>
</tr>
</tbody>
</table>

In level 4 tumours, we preferred using CPB and instituted HCA in majority of the cases. Once the tumour was deemed resectable, the patient was heparinised and cannulation performed. The right atrium was cannulated with minimal handling and avoiding the tumour thrombus. We preferred a low profile ‘Ross basket’ cannula inserted into the right atrial appendage for this purpose. CPB was commenced and the patient was systematically cooled to 15 °C. After attaining the required temperature the patient was placed in Trendelenburg position, bypass discontinued and blood was drained from the patient into the venous reservoir. The RA cannula was removed, cannulation site snuggged and a separate atriotomy made almost to the level of the diaphragm. The intra-abdominal IVC was opened simultaneously by the urologists working within the abdomen. In a bloodless field, the thrombus was gently manipulated and removed from the IVC, hepatic veins and RA. One patient required opening of the main and right pulmonary artery to remove the tumour extension. In patients with supra-diaphragmatic extension of tumour thrombus, there was formation of a ‘tumour waist’ at the level of the diaphragm, which required careful manipulation to deliver the tumour tissue into the abdominal IVC (Fig. 2). Another area of concern was the hepatic veins, which contained ‘tongues’ of tumour tissue and required exploration under vision via RA to extricate. This was further aided by the use of Fogarty’s embolectomy catheter. Once macroscopic tumour tissue was removed, RA and IVC were repaired, CPB was reinstituted and the patient rewarmed.

In these patients, an important aspect of the operation is an early ligation of the renal artery to help decrease the chance of troublesome venous bleeding. In recent times, we have used preoperative renal artery embolisation for this purpose.

Fig. 2. The level 4b tumour thrombus after removal. The distinct tumour waist (W) at the level of diaphragm is evident. The tumour extensions into the hepatic veins (H).
The patients with metastases in this series underwent immunotherapy postoperatively.

3. Results

The distribution of the patients according to the level of tumour thrombus extension into the IVC and the operative strategies used is depicted in Table 2. Twenty-one patients (31%) had metastasis at the time of presentation.

The 30-day mortality in this group was 6% (four patients). There was no mortality in the elective CPB group. One patient with level 3 tumour suffered massive pulmonary embolism and cardiac arrest, while undergoing preoperative preparation in the anaesthetic room. Emergency CPB was instituted and the tumour embolus removed from the main pulmonary artery. However, he could not be weaned off and died. Two other patients died from myocardial infarction in the postoperative period. One patient suffered postoperative pneumonia, developed adult respiratory distress syndrome and died. Four patients were re-explored for abdominal bleeding. Six patients had postoperative renal dysfunction and two of them required haemofiltration. In patients operated with the aid of CPB and HCA, the mean CPB time was 131 min (range 29–193) and HCA was 26 min (range 12–42). The mean intensive care and hospital stay was 2.3 and 14.5 days, respectively.

Mean follow-up time was 31 months (range 2–125). The estimated survival rates at two and five years were 50% and 37%, respectively (Fig. 3). There was no significant difference in survival based on the level of tumour thrombus, although there was a trend for improved survival in patients with level 1 extension (75%) and level 2 extensions (52%) at 5 years (Fig. 4). However, the presence of metastasis significantly affected survival of patients in this study, with no patient with metastasis having 5-year survival as opposed to 48% in patients without metastasis ($P = 0.028$) (Fig. 5).

Cox regression analysis identified the presence of metastases (Odds ratio (OR) 3.1, 95% CI 1.2–8.2) and age > 70 years (OR 2.9, 95% CI 1.3–6.3) as adversely affecting the long-term survival in these patients.

4. Discussion

The involvement of the IVC in renal cancer is generally not a vascular invasion by a malignant tumour, but usually an intraluminal extension of the tumour thrombus mass. Such an intravascular growth indicates increased biological behaviour of the tumour and, if left untreated, is associated with compromised quality of life and poor survival outcome. The resection of the primary renal tumour along with tumour thrombus from the IVC palliates unpleasant symptoms associated with tumour and tumour thrombus, remove life threatening focus of disease, reduce tumour burden before starting immunotherapy and reduce associated problems such as hepatic dysfunction, coagulopathies and nutritional disorders.

In 1913, Berg first described nephrectomy and vena cavo-otomy for RCC extending into the IVC. As illustrated, the survival difference between the infra and supra-diaphragmatic extent was not significant ($P = 0.88$).

![Fig. 3. Kaplan–Meier survival curve of all the operated patients with RCC and IVC.](image)

![Fig. 4. Kaplan–Meier survival curves of the patients according to the level of tumour thrombus in IVC. As illustrated, the survival difference between the infra and supra-diaphragmatic extent was not significant ($P = 0.88$).](image)

### Table 2

<table>
<thead>
<tr>
<th>Level</th>
<th>n</th>
<th>%</th>
<th>Surgical technique and number patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>6</td>
<td>Intrabdominal IVC clamping – 4</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>17</td>
<td>Intrapericardial IVC clamping – 10</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>43</td>
<td>Intrapericardial IVC clamping – 30</td>
</tr>
<tr>
<td>4a</td>
<td>8</td>
<td>13</td>
<td>Intrapericardial IVC clamping – 1</td>
</tr>
<tr>
<td>4b</td>
<td>13</td>
<td>19</td>
<td>CPB – 11 (elective – 10, emergency – 1)</td>
</tr>
<tr>
<td>4c</td>
<td>1</td>
<td>11</td>
<td>HCA – 17</td>
</tr>
</tbody>
</table>

CPB, cardiopulmonary bypass; HCA, hypothermic circulatory arrest; IVC, inferior vena cava.
recognized that venous extension was a potentially curable lesion with a five-year survival rate of 55%, if complete surgical resection could be achieved [9]. Several other investigators reported similar favourable outcomes [3, 10, 11]. Recent reports have suggested that even the presence of distant metastases do not adversely affect survival and an aggressive approach in these patients is advocated [1, 11]. The operative mortality of this aggressive procedure has improved and ranges from 2.7% to 13% [3, 11, 12]. The long-term survival has shown improvement and is reported as 48–68% at 5 years [4].

The diagnosis of IVC involvement and determination of cephalic extent of tumour thrombus is essential to plan a surgical strategy. Complete obstruction of IVC, though not a common presentation, can manifest with clinical features like recurrent pulmonary emboli, pedal oedema, renal or hepatic dysfunction, malabsorption and engorgement of abdominal veins. These patients can tolerate clamping of IVC without significant haemodynamic compromise. However, usually the tumour is non-oclusive or sufficient collaterals have developed and hence these signs are not detected [12]. Ultrasonography supplemented with CT-scan demonstrates the primary tumour and the extent of tumour thrombus in the IVC [1, 12]. Transthoracic echocardiography further delineates the supradiaphragmatic extension of the tumour into the RA and beyond.

The objective of operative management includes complete resection of the primary tumour and tumour thrombus avoiding tumour embolism, minimising blood loss, maintenance of haemodynamic stability and prevention of vital organ ischaemia.

It is generally agreed that when tumour thrombus extends into the RA, CPB with or without HCA is essential for safe and complete extraction of the thrombus [5, 13]. Avoiding circulatory arrest to remove these tumours does have an advantage of shorter bypass time and reduced risk of bleeding. However, there is reduced visualization and exposure, because of presence of blood in the operative field and hepatic congestion.

We advocate the use of HCA in patients with level 4 tumour extensions. There is a bloodless surgical field with decreased risk of cellular spreading and pulmonary embolisation. This not only helps in optimal visualisation of IVC lumen and RA, but also the hepatic veins, which we believe cannot be seen and cleared adequately without a bloodless field. The incomplete resection of these tumours has a significantly higher rate of metastatic recurrence and decreased postoperative survival [1, 3]. Hypothermia also provides protection to various visceral organs.

Other studies have described these advantages of CPB and HCA when dealing with these tumours [1, 14].

The infrahepatic extension of these tumours is best managed by a standard radical nephrectomy with tumour thrombectomy [1, 5]. However, controversy persists regarding the management of tumour thrombus that extends retrohepatically, without extending into the right atrium. These level 2 or 3 tumour extensions can be managed without any form of bypass by achieving control of intrapericardial IVC through thoracoabdominal approach [1, 5]. A fair number of patients in this study were operated with this technique. These tumours can also be removed by isolating and clamping suprahepatic IVC through an abdominal approach [4]. This procedure entails considerable dissection and manipulation of IVC, thereby increasing the risk of operative embolisation. The criticism of the technique involving IVC clamping includes bleeding from hepatic and lumbar veins, or from poor control of the major vascular structures and occasional haemodynamic instability that precludes total resection of the tumour [3, 5]. Dramatic shifts in haemodynamic factors can also contribute to intraoperative death, renal failure and vital organ injury. Venovenous bypass has been advocated in patients who do not tolerate IVC clamping and in whom the tumour extends to the level of the diaphragm [2].

The level of tumour extension into the IVC did not have significant prognostic implication in this series. This is in agreement with other series that demonstrated that the presence of tumour thrombus have limited impact on survival [1, 3]. The 50–55% five-year survival rate of patients with localised renal cancer and 25–75% overall five-year survival rates in patients with tumour extension to IVC has been reported previously and is consistent with the results of this study [4].

The patients with metastatic disease in our series had relatively poor prognosis, similar to that observed by Zisman et al. [15].

5. Conclusion

This study demonstrates that meticulous preoperative planning, intraoperative monitoring, surgical technique and prudent use of CPB and HCA is associated with good short- and long-term outcome in this complex group of patients with RCC extending into IVC.
References


