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Renal-cell carcinoma with intracaval neoplastic extension: stratification and surgical technique

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Summary. Surgical removal continues to be the mainstay in the treatment of renal-cell carcinoma with neoplastic venous extension. The steady improvement of surgical and anesthesiological techniques and the introduction of complete circulatory arrest has dramatically improved the morbidity even of patients with extensive thrombi. If ultrasound or computerized tomography (CT) scanning suggests the presence of a venous extension in a patient with renal-cell carcinoma, cavography, magnetic resonance imaging (MRI), transesophageal color-coded ultrasound, and echocardiography may be needed to resolve the questions of cranial extension and vascular wall infiltration. Surgical stratification and, thus, classification of the venous extension depend on the potential need for complete circulatory arrest. Surgical removal is done en bloc for smaller venous extensions and in a two-step procedure (radical nephrectomy followed by thrombectomy) for more extensive thrombi. In patients with infiltration of the suprahepatic inferior vena cava, the hepatic veins or atrium, pending thrombotic embolism, or large masses of suprahepatic thrombotic material, the use of cardiopulmonary bypass and complete circulatory arrest is recommended.

In 1993, renal-cell carcinoma was diagnosed in more than 27,000 patients in the United States [2]. Approximately 30%–40% of the patients presented with metastatic disease at the time of diagnosis [3], with another 4%–10% showing intracaval neoplastic extension [13]. Depending on the series, 10%–25% of these patients with renal-cell carcinoma and intracaval neoplastic extension have been found to have extension above the hepatic vein up to the right atrium or even within the right ventricle [4–7, 9, 12–16]. Since surgical removal is the mainstay in the treatment of renal-cell carcinoma, complete removal of the renal tumor with its venous extension should be offered to patients without metastases. However, since newer adjuvant therapeutic modalities for parenchymatous metastases of renal-cell carcinoma appear to be more effective and anesthesiological and surgical techniques continuously improve, we feel that surgical removal of these tumors should also be offered to patients in a good general condition despite the presence of metastases.

This report demonstrates our diagnostic and surgical experience with renal-cell carcinomas and neoplastic extension into the inferior vena cava. Our experience is based on the surgical removal of intracaval neoplastic extensions of renal-cell carcinomas in 78 patients since 1978. Of these patients, 62 exhibited caval thrombi below or at the level of the hepatic veins; 5, with extensions above the hepatic veins but not protruding into the right atrium; and 11, with intraatrial extension. During the observation period we have observed an increase in the number of patients with this specific entity parallel to an increasingly aggressive surgical attitude toward advanced thrombus extension due to improved anesthesiological and surgical techniques. Thus, nine patients with suprahepatic extension have been surgically treated at our institution between 1978 and December 1993, as have another seven patients with this entity during the last 14 months.

Diagnostic approach

All our patients with renal-cell carcinoma and neoplastic extension into the vena cava were secondary referrals due to the venous extension. Regarding imaging modalities, most patients in this series presented with ultrasound scanning, i.v. pyelogram, and computerized tomography

Table 1. Rationalized diagnostic approach for surgical decision making in patients with renal-cell carcinoma and neoplastic extension into the vena cava

Step 1 –	Ultrasound- or CT-based suspicion of intracaval extension: Cavography
Step 2 –	Suspicion of suprahepatic extension or caval wall adherence: MRI plus color-coded duplex sonography
Step 3 –	Suspicion of intracardial extension: Echocardiography

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(CT) scans. On the one hand, as in other centers, the general availability of ultrasound scanning has increased the number of renal-cell cancers diagnosed in an early stage during the course of disease, and, on the other hand, it has enabled the referring general practitioner or the specialist to transfer most of the patients in the category with suspected venous involvement.

Previously, these patients received an extensive diagnostic workup that routinely included ultrasound scanning of the large vessels, renal arteriography, cavography, magnetic resonance imaging (MRI), spiral CT, echocardiography, and color-coded duplex sonography. These diagnostic procedures, however, proved to be time-consuming and costly. Therefore, we rationalized our diagnostic approach for patients with vena cava involvement without compromising any important diagnostic information needed for surgical stratification (Table 1). With increasing experience, a number of these investigations have become redundant. This rationalized diagnostic approach focuses on tumor extension with respect to surgical decision making but not to the search for metastatic disease.

Should neoplastic venous extension be suspected in a patient with renal-cell carcinoma, cavography is done first. Should cavography reveal a small extension into the vena cava, further diagnostic procedures are not required. Should the tumor extend up the vena cava, the technical demands for efficient surgical removal increase significantly. Usually, more extensive caval thrombi occlude the caval lumen completely or almost so; therefore, cavography does not give any precise information with regard to the cranial aspect to the thrombus or its relation to the caval wall. Because information on the cranial extension of the thrombus, on its possible infiltration into hepatic or vertebral veins, and on its adherence to or invasion of the vascular wall is of crucial importance for the surgical strategy, MRI (Fig. 1) and transesophageal color-coded duplex scanning [8] are mandatory to demonstrate the presence of a more extensive thrombus. In case an atrial or even ventricular extension is suspected, echocardiography should be performed for accurate evaluation regarding the extension of the neoplastic thrombus (Fig. 2).

Fig. 1. In a 65-year-old woman, MRI delineates the cranial extension of an intracaval neoplastic extension *(arrow)*

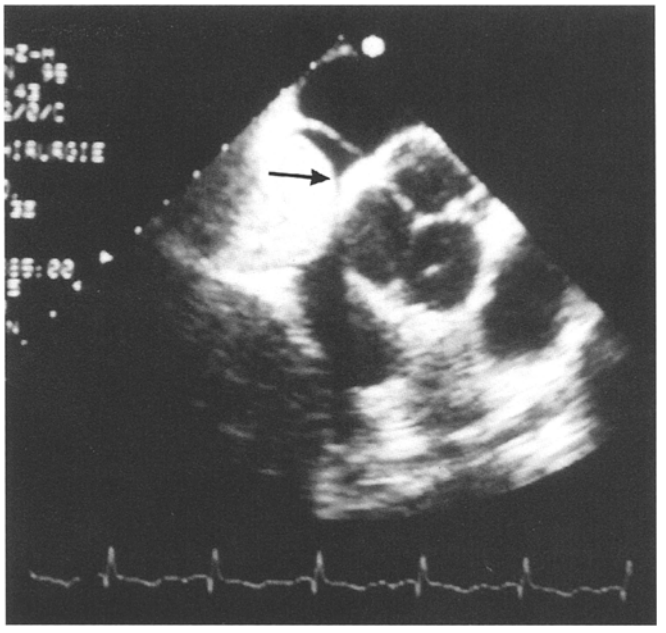


Fig. 2. Transesophageal echocardiography demonstrates a venous neoplastic extension in the patient illustrated in Fig. 1. The tumor completely obliterates the inferior vena cava. A large portion of the right atrium is occupied by the tumor extension, which is also in close proximity to tricuspid valve and aortic root *(arrow)*

Surgical stratification

It is well documented in the literature that a multidisciplinary approach involving the combined use of deep systemic hypothermia, cardiac arrest, temporary exsanguination, and cardiopulmonary bypass has dramatically improved the feasibility and results of surgical treatment of neoplastic caval thrombi above the hapatic veins [1, 4–7, 9–16]. In our experience, during the past 14 months this urological-cardiosurgical approach has enabled a much more aggressive surgical treatment for patients with advanced local disease without affecting morbidity or mortality. In fact, the operating time (260–310 min) and blood loss could be kept within reasonable limits in these patients due to the carefully planned combined approach, although additional surgery was often needed (e.g., for pulmonary metastases, colonic infiltration, or thrombi in both pulmonary arteries). For example, the operating time required for the patient shown in Figs. 2 and 3, who had a large tumor invading the pancreatic tail and spleen that necessitated removal of both, was 310 min.

From the urologist's standpoint, the most important preoperative question in patients with renal-cell carci-

noma and neoplastic extension into the inferior vena cava is whether the individual case can be safely managed without the need for cardiac arrest and cardiopulmonary bypass. These cases cover small intracaval protrusions and larger intracaval thrombi with a definitive infrahepatic cranial margin (type 1; Table 2).

In all other patients, surgery should be done in a location where cardiopulmonary bypass and the options of deep systemic hypothermia and temporary exsanguination are readily available (type 2). However, patients with suprahepatic neoplastic extension may be safely managed without cardiopulmonary bypass (type 2a, Table 2; the surgical procedure is discussed below) using various maneuvers, although the need for circulatory arrest cannot be definitely ruled out preoperatively. In a recent patient the preoperative information indicated a free-floating thrombus extending up to the right atrium, and we subsequently planned cavotomy plus Pringle's maneuver [11] and thrombus extraction without circulatory arrest (type 2a). However, intraoperatively, an extensive infiltration of the neoplastic thrombus in the suprahepatic cava (Fig. 4) was revealed that required institution of cardiopulmonary bypass and deep systemic hypothermia (type 2b).

A subset of patients with renal-cell carcinoma and intracaval neoplastic extension definitely require the use of cardipulmonary bypass with deep systemic hypothermia and temporary exsanguination (type 2b). These cases include infiltration of the suprahepatic inferior vena cava, the hepatic veins, or the atrium; pending thrombotic embolism; or large masses of suprahepatic thrombotic material.

Table 2. Surgical stratification of neoplastic extensions into the inferior vena cava

Type 1 –	No need for systemic circulatory arrest:
	Small intracaval protrusions
	Intracaval thrombi with a definite infrahepatic cranial margin
Type 2 –	Infrastructure for systemic circulatory arrest must be readily available:
	Type 2a – Need for systemic circulatory arrest possible but unlikely:
	Suprahepatic but infradiaphragmatic intracaval extension
	Supradiaphragmatic extension of free-floating thrombus
	Type 2b – Need for systemic circulatory arrest definite:
	Infiltration of the suprahepatic inferior vena cava, the hepatic veins, or the right atrium
	Pending thrombotic embolism
	Large masses of suprahepatic thrombotic material

Surgical strategy

The basic idea of our surgical strategy is to find an optimal equilibrium between complete surgical removal of the renal tumor, including the neoplastic caval thrombus, and minimal morbidity and mortality for the patient. Since severe bleeding is rarely found during excision of the renal tumor, we do not advocate preoperative embolization of the renal artery of the tumor-bearing kidney.

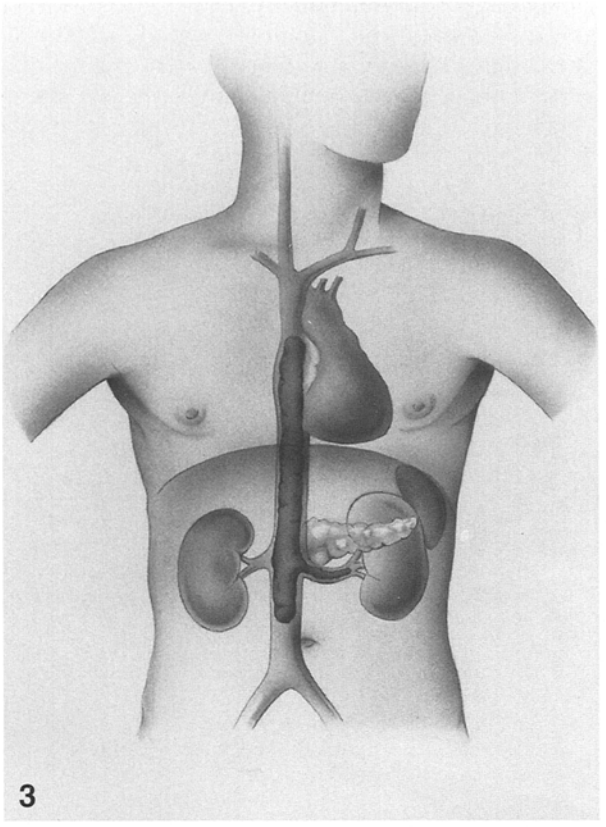
Tumors with type 1 thrombi allow a wide variety of surgical incisions that mostly depend on the tumor size and the surgeon's individual preference. For right-sided tumor, we prefer a thoracoabdominal approach or a right "hemichevron" incision. For left-sided tumors, a "chevron" incision seems to be best suited for removal of the tumor from a left laterocolic approach and to provide optimal caval exposure from a right laterocolic approach.

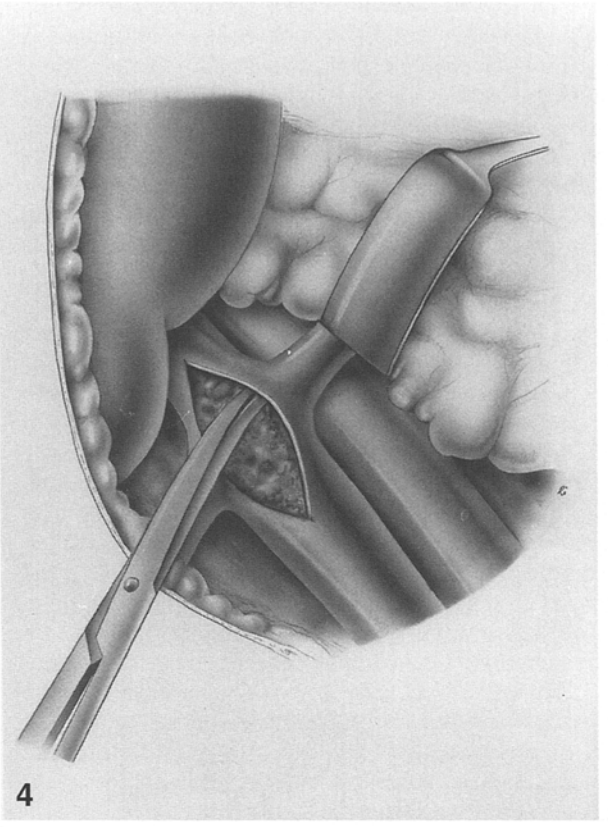
Except for patients with a history of pulmonary embolism or a pending embolism, we first mobilize the kidney within Gerota's fascia en bloc with the adrenal gland. After ligating and cutting the ureter and renal artery, we dissect the vena cava below the renal veins up to the level of the hepatic vein; the contralateral renal vein is also dissected. In the case of a small intracaval thombus protrusion, we use one (or in larger thrombi, two) Satinsky clamp(s) on the perirenal inferior vena cava, excising the renal vein to allow en bloc resection of the renal tumor and the thrombus. In a larger infrahepatic thrombus, we place vascular clamps on the infrarenal cava, the contralateral renal vein, and the infrahepatic vena cava; the lumbar veins are clipped. The renal vein is then resected to allow en bloc resection of the renal tumor (Fig. 4) and, finally, the caval incision is closed with a 4.0 polypropylene running suture (Fig. 5).

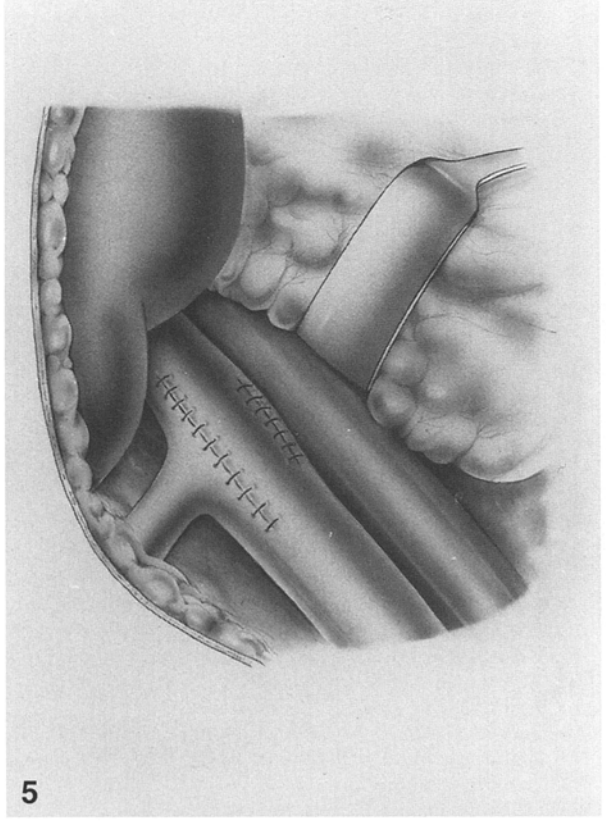
Since sternotomy may be required in type 2 thrombi, we exclusively use the chevron or hemichevron incision as described above. In patients with a history of pulmonary embolism or a pending embolism, the vena cava is first dissected above the thrombus, mostly at the infradiaphragmal level, and a vessel loop is placed around the cava, which is then slightly constricted. In all other cases, we initially perform a formal radical nephrectomy (if indicated, with excision of adherent organs). To minimize blood loss in the case of complete circulatory arrest and subsequent heparinization, we perform the radical nephrectomy in type 2 cases separately from the removal of the thrombotic material; the renal vein is double-clamped; the renal tumor, removed; and the thrombus fixed to the renal vein stump by a suture ligature. To reduce the need for heterologous blood transfusion, a cell saver is used for caval dissection (until the cava is opened) and, if necessary, for the intrathoracic part until the atrium is opened.

The vena cava is dissected below the renal veins up to the level of the hepatic veins. The contralateral renal vein is dissected; existing lumbar veins are ligated and transsected. If at this stage the cranial margin of the thrombus can be palpated at or below the level of the hepatic vein, clamps are placed as described above. We incise the vena cava longitudinally on the anterior aspect, evert the thrombus, excise the renal vein from the inside, and extract the thrombus. Cavotomies are closed with running sutures (Fig. 5).

Should the thrombus reach up to the intrahepatic vena cava but below the diaphragm and be floating freely, the liver is mobilized [11] and the liver hilum and the cava are







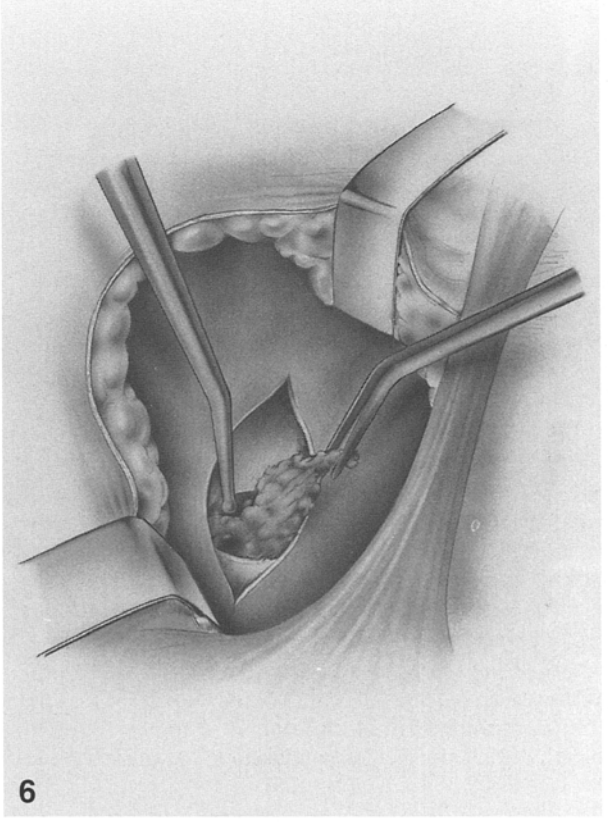


Fig. 3. Schematic drawing illustrating an intracaval and intraatrial neoplastic extension as well as infiltration of the pancreatic tail

Fig. 4. Sharp dissection of a closely adherent intracaval neoplastic extension is done in a bloodless field

Fig. 5. Cavotomy and excision of the renal vein are closed by running sutures

Fig. 6. Schematic drawing illustrating the incision of the right atrium and extraction of the neoplastic thrombus from the inferior vena cava

clamped infradiaphragmatically (as are the inferior vena cava and the collateral renal vein). Excision and extraction are done as described above. In case the thrombus is floating freely from the intrahepatic area up to the atrium, a similar approach is chosen, but without infradiaphragmatic clamping of the vena cava. With the liver and inferior vena cava being retracted, a clamp is placed on the cava below the diaphragm or intrapericardially. After incision of the cava and eversion of the thrombus, a clamp is placed on the infrahepatic vena cava, the first clamp is removed, the liver circulation is restored, and the procedure is continued as described above.

Surgical incision and removal of the renal mass for type 2b tumors is comparable with that for type 2a tumors. Similarly, the vena cava is dissected infrarenally to the hepatic veins. Following sternotomy and opening of the pericardium, cardiopulmonary bypass, deep systemic hypothermia, cardiac arrest, and temporary exsanguination are implemented. We incise the vena cava longitudinally on the anterior aspect, evert the thrombus, excise the renal vein from the inside, and extract the thrombus. If the thrombus is adjacent to the caval wall, sharp dissection is done. To assure complete removal of the thrombotic material, the atrium is opened and possible thrombotic material is removed (Fig. 6). The inferior vena cava and the hepatic veins are then carefully inspected for remaining thrombi or residual fragments infiltrating or coating the vascular walls. After their removal, the atrial and caval incisions are closed with running sutures.

Comments

Complete surgical removal remains the therapeutic goal in patients with renal-cell carcinoma and neoplastic venous extension. Due to increasing experience and application of vascular and cardiac surgical techniques, this approach is feasible in most instances despite extensive tumor growth. If the neoplastic extension remains caudal to the hepatic veins, desobliteration of the inferior vena cava following simple clamping appears to be appropriate and, in the absence of adhesions between the tumor and the vascular wall in this region, results in limited blood loss and morbidity. In patients with extension to the perihepatic inferior vena cava, temporary occlusion of the hepatic hilum may aid in safe and rapid tumor extraction. In more complex cases and tumor extension above the diaphragm, the use of cardiopulmonary bypass, deep hypothermia, and circulatory arrest allows complete tumor removal without significantly increasing morbidity or mortality. For the last cohort of patients, desobliteration of the inferior vena cava has been feasible in all instances, with no residual tumor being left behind. The negative short- and long-term complications of alloplastic venous replacement can thus be avoided. For adequate planning of the surgical strategy, cavography, MRI, transesophageal color-coded ultrasonography, and echocardiography appear to be sufficient. Additional cardiovascular diagnostic procedures may include Doppler sonography of carotid arteries and coronary angiography in a few selected patients.

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