Venous spread of renal cell carcinoma: MDCT

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Title: Venous spread of renal cell carcinoma: MDCT

Short title: Venous spread of RCC

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Abstract

Background: The purpose of our study was to present multidetector computed tomography (MDCT) findings in venous spread of renal cell carcinoma (RCC), to determine the superior extent of tumor thrombus and to compare MDCT findings with surgical report.

Methods: The prospective MDCT study was performed on 31 patients diagnosed with RCC with venous spread (19 males and 12 females; age range 39 - 80 years; mean age 62.6 years). CT scans were obtained by MDCT scanner, in triphasic scanning protocol. All postprocessing techniques were performed by two independent radiologists, and the findings were reported in their consensus. MDCT diagnosis was compared with surgical and pathohistological findings.

Results: Tumor thrombus extension into renal vein only (T3b stage) was found in 13/31 (42%) patients. Involvement of infradiaphragmatic level of inferior vena cava (IVC) (T3c stage) was found in 14/31 (45%) patients and supradiaphragmatic level of IVC (T4b stage) in 4/31 (13%) patients. In 27/31 (87%) patients surgery was performed, while 4/31 (13%) could not undergo surgery. In comparison with surgical report, in 25/27 (93%) operated patients the upper extent of the tumor thrombus was correctly diagnosed by MDCT, and 2/27 (7%) patients were falsely diagnosed.

Conclusion: MDCT represents a fast, relatively inexpensive, and reliable diagnostic method for evaluating the venous spread of RCC as well as the level of its upper extent. Triphasic MDCT is often the only diagnostic method necessary for planning the surgical procedure. Surgery should be performed as soon as possible for MDCT findings to be valid.

Keywords: Renal cell carcinoma, Multidetector computed tomography, Staging, Renal vein, Inferior vena cava

Renal cell carcinoma (RCC) is the single most common renal malignancy, accounting for 85 - 90% of adult renal malignancies, with a male to female predominance of approximately 2.5:1 [1]. As a reflection of its biological aggressiveness, the tumor invades the venous system in 4% to 10% of cases [2-5]. Venous system is usually involved in the case of large tumors, high-grade tumors, and high-stage tumors [6]. The venous tumor invasion starts from microscopic intrarenal veins [7], spreading to renal sinus veins [8], renal vein, and inferior vena cava (IVC), up to right atrium in extreme cases. Involvement of IVC is more common with right-sided lesions [9, 10].

The only efficient and curative treatment in localized and advanced RCC is radical surgery [11, 12]. Therefore, detailed preoperative staging is necessary for proper surgical planning [13]. A survival rate of patients with RCC depends on local tumor expansion, as well as the level of venous involvement and the presence of distant metastases [14, 15].

For many years computed tomography (CT) represented the first choice for evaluation of tumor extension due to its high accuracy [16, 17]. The latest generation of CT device, multidetector CT (MDCT), enables the further improvement of precision in evaluation of tumor extension. MDCT uses high-speed acquisition and due to its technical characteristics enables high-quality images without artifacts and 3D postprocessing [18, 19] (Fig. 1).

MDCT has shown to be highly accurate in the diagnosis of spread of RCC into the venous system. The level of venous involvement, the distal and proximal extension of the thrombus and infiltration of the venous wall dictates the surgical approach [13].

The purpose of our study was to analyze the findings of MDCT in venous spread of RCC, to determine the superior extent of tumor thrombus and to compare MDCT and surgical findings.

Materials and methods

The prospective study was performed on 31 patients (19 males and 12 females; age range 39 - 80 years; mean age 62.6 years), in the period from January 2002 to December 2005. The patients in the study were all diagnosed with RCC with venous spread. RCC was previously detected by ultrasound in all patients and afterward they were preoperatively scanned.

CT scans were obtained by using MDCT scanner (General Electric Medical System, LightSpeed Ultra 16 Slices per Second, Milwaukee, WI, USA). Our CT study protocol consisted of native and triphasic contrast-enhanced CT imaging (arterial, venous and excretory phases) with Smart Prep (GE Medical Systems) scan delay; using Optidose Feature (dose optimization program). All patients received 100-120 mL of iopromide, nonionic contrast media (Ultravist 300, Schering, Germany) using automatic injector through an 18-gauge peripheral venous access at a flow rate of 4mL/s. Reconstructed slice thickness was 2.5mm with 50% overlap of reformatted images for both the precontrast and the postcontrast scans. Reconstructed data were transferred from the scanner to a three-dimensional workstation (Advantage Workstation, ADW 4.2, GE Medical Systems).

All postprocessing techniques were performed by two independent radiologists (professor of radiology and radiology specialist experienced in genitourinary imaging), and the findings were reported in their consensus. Both radiologists had similar experience in CT interpretation. During the examination, the readers had insight only to the clinical data, but none of the surgical and pathohistological findings. Diagnosis of venous spread of RCC was made on the basis of characteristic CT findings. All tumors were staged according to TNM classification [20].

MDCT diagnosis was compared with surgical and pathohistological findings.

Results

We analyzed MDCT findings of 31 patients with venous spread of RCC in order to determine the upper extent of the venous thrombus and to compare the findings with the surgical reports.

Venous extension was classified using TNM classification, where T3b stage meant existence of tumor thrombus in renal vein only, T3c stage involvement of infradiaphragmatic part of IVC, and T4b stage supradiaphragmatic part of IVC [13].

MDCT showed right-sided tumor in 19/31 (61%) patients and left-sided tumor in 12/31 (39%) patients.

Tumor thrombus extension into renal vein only (T3b stage) was found in 13/31 (42%) patients. Involvement of the infradiaphragmatic level of IVC (T3c stage) was found in 14/31 (45%) patients and supradiaphragmatic level of IVC (T4b stage) in 4/31 (13%) patients.

In 27/31 (87%) patients surgery was performed, while 4/31 (13%) could not undergo surgery, because three patients refused surgical treatment and one patient had extensive tumor with distant metastases (T3cM2) (Fig. 2).

In comparison with the surgical report, in 25/27 (93%) operated patients the upper extent of the tumor thrombus was correctly diagnosed by MDCT and 2/27 (7%) patients were falsely diagnosed. Both falsely diagnosed patients were understaged. In those cases MDCT showed T3b stage, while surgery reported T3c stage. In both cases we noticed that surgery was performed at least 1 month after MDCT diagnosis, while in others surgery followed the MDCT scanning immediately.

Imaging findings

Analyzing the triphasic contrast-enhanced MDCT images, we assessed the tumor mass and the existence of venous thrombus, as the low-attenuation filling defect inside the lumen of the vein (Fig. 3). Helpful accessory finding for determining the venous thrombus was a significant change in renal vein caliber (Fig. 4). Enlargement of the renal vein is not sufficient evidence itself because it can occur as a normal variant. MDCT appearance of the thrombus enabled the differentiation between the bland thrombus and tumor thrombus extending in continuity from the tumor mass itself. Contrast enhancement of the thrombus indicates the tumor mass. In our study renal mass and thrombus inside renal vein only were observed in patients diagnosed with T3b stage (Fig. 5). Patients diagnosed with T3c stage, beside the renal mass and filling defect in the renal vein, had the thrombus extended upward to infradiaphragmatic part of IVC (Fig. 6). In one patient with T3c stage we observed also a tumor infiltration of the venous wall (Fig. 7). In T4b stage MDCT showed thrombotic mass extending upward to supradiaphragmatic part of IVC while some patients had the thrombus extended into the right atrium (Fig. 8). However, one patient had thrombus extended also into infrarenal part of IVC and into right hepatic vein (Fig. 9). Among the patients with T4b stage, one had massive tumor thrombus in IVC that infiltrated the venous wall and extended into the right atrium, which was characterized on MDCT as heterogeneously contrast enhanced mass, which indicated neovascularity inside the thrombus (Fig. 10).

Discussion

According to most published studies involvement of venous system in RCC is between 4% and 10% [21-23]. The renal vein is reported to be involved in 23-25%, while IVC was involved in up to 10% cases [4, 11]. It is also recorded that thrombus spread into the right atrium is evident in 2 -16% cases [24-26].

Venous system invasion within RCC is a reflection of the biological aggressiveness of the tumor and implicates poorer prognosis. Some authors report that venous invasion is more often in tumors with larger diameter, higher grade, and higher stage tumors [6]. Most of the published studies show that the level of the venous involvement in RCC does not affect the long-term survival rate, and that more important prognostic factors are the local tumor extension, regional nodal involvement and the presence of metastatic disease. Other adverse prognostic indicators include high pathological grade, sarcomatoid histology, large tumor size (> 10 cm), weight loss, hypercalcemia, and an elevated sedimentation rate such as the histological type of the tumor [27].

Regarding various studies, a 5-year survival rate of patients with RCC spread into IVC without venous wall invasion is between 32% and 64% [10, 28]. Hatcher et. al. [4] reported the difference in the 5-year survival rate in patients with floating thrombus (69%) compared with patients with IVC wall infiltration (25%). The presence of the thrombus inside the lumen of the vein that does not adhere the venous wall does not change the prognosis, but can have a significant impact on the surgical approach.

The radical surgical procedure represents the only efficient treatment of RCC. Depending on the level of venous involvement, the surgical approach differs. In the case of invasion of the renal vein and infradiaphragmatic part of IVC, abdominal approach is required, as well as examination of IVC above and below the level of the tumor. If the tumor involves retrohepatic part of IVC, the approach must be thoracoabdominal, with the examination of intrapericardial part of IVC. The spread of the tumor into the right atrium requires sternotomy with cardiopulmonary bypass, and even, if necessary, deep hypothermic circulatory arrest [29-32]. According to all of the above, accurate preoperative assessment of the spread of RCC is

crucial for choosing the surgical approach. Nephron-sparing surgery is an alternative to the radical surgical procedure in earlier stages of RCC. The most suitable lesion for this type of surgery is the one with <4 cm in diameter, situated cortically, on the pole of the kidney, far from the hilum and collecting system. Accurate assessment of intrarenal spread of RCC, infiltration of renal pelvis, renal vessels and perirenal fat tissue is necessary for planning the nephron-sparing surgery [33, 34]. In patients who are not surgical candidates, accurate staging gives important information considering the prognosis.

Robson's and TNM system represent the two most widely used classifications for staging of RCC. Most of the authors preferred the Robson's classification, which was older and simpler. However, more authors in radiological papers have recently begun to use TNM classification. The main difference between Robson's and TNM classification systems is in grouping of the patients with venous spread of the disease and the affection of the lymph nodes. TNM classification was developed by International Union Against Cancer (UICC) in 1978. and has been revised several times in order to improve international communication. Unlike Robson's classification, TNM classification gives more details and divides patients in more subgroups [35].

"The golden standard" in detection of the upper extent of the thrombus traditionally was DSA cavography, with sensitivity of 100%, considering published studies [36, 37]. By developing the new imaging methods, CT and MRI, the use of DSA cavography becomes less.

CT has been the method of choice in assessment of spread of RCC over the years. The main objective of preoperative CT is to determine the extent of the primary tumor, to detect venous spread and the existence of local and distant metastases. Johnson et al. [16] reported the sensitivity of 78% and specificity of 96% for determining the venous invasion. Overall accuracy of CT in this study was 91%. Further improvement in diagnostic imaging was accomplished by development of the spiral technology in CT imaging. Welch and LeRoy [38] provided their data for helical and electron-beam CT, where sensitivity was 85%, specificity 98% and accuracy 96% in preoperative CT evaluation of existence of venous thrombus. Finally, developing the multidetector CT and by using triphasic postcontrast

enhancement protocols, high precision in detection of venous spread of RCC was achieved. CT scanning protocol, which combines the native CT and corticomedullary, nephrographic and excretory phases, was proven optimal. It is very important to emphasize that in some cases IVC filling defect seen on CT is pseudothrombosis caused by laminar flow of enhanced blood from renal veins streaming parallel to the column of unopacified blood returning from the lower body or as a result from poorly enhanced blood. Delayed images to show resolution of the filling defect are usually sufficient to confirm the artifactual nature of such pseudothrombosis [39]. High resolution MDCT protocol was proved to be correct in identification of thrombus in renal vein and IVC, with the higher radiation dose to the patient as a main drawback [40].

Our results of preoperative assessment of upper extent of the venous spread of RCC by using the triphasic MDCT protocol are very similar or identical to the most of the recently published studies. Several studies published over the past few years compared the accuracy of MDCT and MRI in staging of RCC, also comparing several independent readers, and reported high accuracy of MDCT in delineation of the upper extent of the thrombus with a sensitivity of 93% and a specificity of 80%. MRI has similar sensitivity and specificity as MDCT in staging of the venous expansion of RCC, so these two methods are comparable [41, 42]. Recently published study by Lawrentschuk et al. also showed the complete accuracy of MDCT in detection of the upper extent of the tumor thrombus compared with surgical report. In that study, MDCT was accurate in all the eight cases [43].

The limitation of our study was that we did not calculate accuracy, sensitivity, and specificity for each reader separately.

Conclusions

MDCT represent fast, relatively inexpensive, and reliable diagnostic method for evaluating the venous spread of RCC as well as the level of its upper extent, from renal vein to right atrium. Triphasic MDCT protocol gives enough information about tumor spread, and is comparable with MRI. MDCT is often the only diagnostic method necessary for planning the surgical procedure. Surgery should be performed as soon as possible for MDCT findings to be valid.

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Figures text

Figure 1

MDCT is offering high-quality images. Optimal MDCT scanning protocol is combining native CT and corticomedullary, nephrografic and excretory phases as well as 3D postprocessing.

A-D A 60-year-old women with RCC in the middle portion of duplex kidney with duplication of the caliceal system and ureters. Axial slice and multiplanar reformation (corticomedullary, nephrografic, and excretory phases), all of three veins are free of thrombus.

Figure 2

A 70-year-old man unenhanced CT scanning was performed due to the patient's poor condition and renal insufficiency.

A, B Multiplanar reformation and axial slice, large inoperable RCC in the left kidney, perirenal infiltration, distant metastases in the right adrenal gland (black arrow) and in the retrocrural lymph nodes (small white arrows).

C Dilated left renal vein, inhomogeneous structure of renal vein and IVC, low attenuation of blood, suspected thrombus in the renal vein and in the IVC.

D Distant metastases in the lungs and thoracic wall (large white arrow).

Figure 3

A 66-year-old women. The most specific sign of venous extension is a presence of a low-attenuation filling defect within the vein.

A Coronal view, RCC in the lower pole of the right kidney without visible thrombus.

B Thrombus in renal vein (arrow) is visible due to minimal change in projection.

Figure 4

A 68-year-old woman with left sided RCC. Change in renal vein caliber is helpful accessory finding for determining the venous thrombus.

A Multiplanar reformation, oblique view, large tumor in the left kidney (white arrow), suppressed and dilated ovarian and perirenal veins.

B Axial slice, low-attenuation filling defect in the dilated renal vein as a sign of the thrombus (arrow).

Figure 5

A 49-year-old man.

A, B Multiplanar reformation, tumor mass in the lower pole of the left kidney, thrombus in the peripelvic part of renal vein (arrows).

A 52-year-old man.

C, D Multiplanar reformation, tumor mass in the upper pole of left kidney, two veins, in the upper vein partial thrombosis (arrows).

A 62-year-old woman with RCC.

E, F Axial slice and multiplanar reformation, tumor mass in the upper pole of left kidney, consequently dilated perirenal veins and lumbar vein, several renal veins, thrombus in one of renal veins (arrow).

Figure 6

A 70-year-old women.

A RCC in the right kidney, tumor thrombus fulfills right renal vein and gets in the infradiaphragmatic level of IVC (white arrow).

A 54-year-old man.

B Large RCC in the right kidney, thrombus into the infradiaphragmatic level of IVC (black arrow).

A 45-year-old women.

C RCC in the left kidney, floating bland thrombus into the infradiaphragmatic level of IVC (white arrows).

Figure 7

A 62 year-old-man, multiplanar reformation, RCC in the left kidney, tumor thrombus extension into the infradiaphragmatic level of IVC, and invasion of venous wall.

Figure 8

A 56-year-old women.

A, B Multiplanar reformation, RCC in the middle portion of the left kidney, thrombus extends from the renal vein into the supradiaphragmatic level of IVC and into the right atrium (arrows).

Figure 9

A 75-year-old man with RCC into the right kidney.

A-D Axial slices, thrombus from IVC gets into the right hepatic vein, with disturbance of liver circulation as consequence (Budd-Chiari syndrome).

E Multiplanar reformation, thrombus extends into the renal vein, supradiaphragmatic and infrarenal part of IVC and hepatic vein (arrows).

Figure 10

A 62-year-old man with massive tumor thrombus into the supradiphragmatic level of IVC and into the right atrium. Tumor thrombus extends from the right kidney into the right renal vein, the IVC, and the right atrium as well as infiltrates venous wall.