

## Vascular anatomical variants in renal surgery: classic and robotic approach

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### Abstract

**Introduction and Objectives:** Conservative renal surgery is based on the nephron-sparing principle. Renal arterial vascularization is of terminal type and the occlusion of an artery generates the necrosis of the corresponding region. The aim of this research is to analyze the anatomic particularities of the renal vascular system as they are highlighted in the course of standard and robotic surgeries. **Patients and Methods:** Between May 2006 and November 2010 we have performed 35 partial nephrectomies out of which 30 cases (85.7%) were performed by standard surgical approach and the other five (14%) were robot-assisted. In the same interval, we have done 103 pyeloplasties to obstruct the pyeloureteral junction: 65 (63%) were carried through by standard surgical approach, 32 (31%) by laparoscopic approach and six cases (6%) were robot-assisted. **Results and Discussion:** In 20 (54.3%) of cases, nine (25.7%) had two renal arteries (both superior and inferior), five (14.2%) had early ramifications of the renal artery outside the renal sinus, four (11.4%) patients showed two renal veins, one patient lacked the prepyelic venous plane, and in one patient we have found duplicate abdominal vena cava. Out of all the pyeloplasty cases, 31 (30%) showed an obstruction of the renal collecting system by crossing with a segmental artery or with a vein. **Conclusions:** Efficient renal surgery implies good knowledge of anatomical particularities of the renal vascular. The minimally invasive approach by robotic laparoscopy remains an essential coordinate in renal surgery and allows an efficient preparing of the vascular capital.

**Keywords:** renal artery, kidney tumor, nephron sparing, ureteropelvic obstruction.

### Introduction

The “nephron sparing” technique is a widely discussed topic and a current theme in urology in the light of current technical possibilities and of oncologic result [1, 2]. The minimally invasive approach had gained in popularity along with progressing laparoscopic surgery and it has reached its point of maximum interest with the help of robot-assisted surgery. Among the advantages of minimum invasiveness are the increased degree of security, the elegance of intracorporeal sutures, the increased efficiency of the surgical interventions, and a faster socio-professional reintegration. It is imperative that oncologic principles are not compromised [3, 4]. A crucial moment in renal resection surgery is the warm ischemia time that can irreversibly endanger renal function. Partial nephrectomy has been attempted by laparoscopic approach in local hypothermia [5, 6], but the complexity and incurred risks are the premises of the exceptional selection of this technique. [7] On the long term, the “nephron sparing” technique for stage T1 (*TNM 2009 Staging Classification*) small renal tumors generates results that are similar to those of radical nephrectomies and it is also advantageous as it preserves renal function [8–10]. Specific survival five years after partial nephrectomy for T1 stage renal carcinoma is of 96%.

Partial nephrectomy can be a bloody surgical intervention. In this context, vascular control plays a

crucial role and to ensure the efficiency and security of the renal segmental excision we must have in mind the position and the available vascular variants. According to *Anatomical Terminology* [11], the renal artery divides into an anterior and a posterior branch. The anterior branch also divides into four segmental arteries: superior, anterior-superior, anterior-inferior and inferior. The renal artery has quite often a larger number of branches. Multiple renal arteries occur in 20–25% of cases. Venous drainage is described on two separate planes: an anterior and prepyelic plane and a posterior and retropyelic plane. In many cases, an absence of retropyelic collecting veins has been observed.

The branches that irrigate the inferior renal pole can cross and even incarcerate the ureter promoting renal obstruction [12]. In 40% of cases, the cause of mechanic obstruction is an aberrant or supernumerary vessels or a segment with early emergence from the vascular segment of the inferior renal pole [13]. In 1993, Kavoussi and Schuessler reported the first laparoscopic pyeloplasty case. The dissection plans, the preparation of the pyeloureteral junction and the isolation of the aberrant vascular pedicle can be efficiently performed by laparoscopic or robot-assisted lomboscopy [14].

### Patients and Methods

Between May 2006 and November 2010, we have performed 35 partial nephrectomies for tumoral

pathology: 30 (85.7%) were done by standard retroperitoneal laparoscopy and five (14%) were robot-assisted. Out of these five cases, in four cases we have used lomboscopy, while transperitoneal approach was used for only one patient. The group of patients included 24 men and 11 women with ages between 36 and 77 years (an average age of 58 years). CT/RMN showed renal tumor formations for all patients.

During the same timeframe, we have performed 103 pyeloplasties to obstruct the pyeloureteral junction. In 65 (63%) patients, the surgery was carried out by standard, retroperitoneal approach. The laparoscopic approach was used for 32 patients (31%) and out of these 32, we have used approach for four patients, six cases (6%) were robot-assisted: four by lomboscopy and two by transperitoneal approach. The group of patients consisted in 57 men and 46 women with ages between 10 months and 82 years, with an average age of 31 years. We have confirmed the presence of obstruction in all the patients included in the study by radiology tests. Also all the patients showed a primary obstruction of the ureteropelvic junction. The same urologist coordinated the surgeries.

## Results

High-resolution imaging techniques did not set the exact number of patients with renal or abdominal vascular capital. Therefore, the number of intraoperative determined vascular variants surpassed the CT/RMN determined expectancy. The renal pedicle with a single artery, vein and a single normal segmental branch and which was intraoperatively exposed was found in 45.7% of the cases where the “nephron sparing” technique was used.

Dissection and selective preparation of the renal hilum is easier in these cases, but the skeletonisation of vessels is more efficient when using a robot-assisted approach compared to open surgery.

Results of renal pedicle surgical exploration, nine patients (25.7%) had a double renal artery, with different

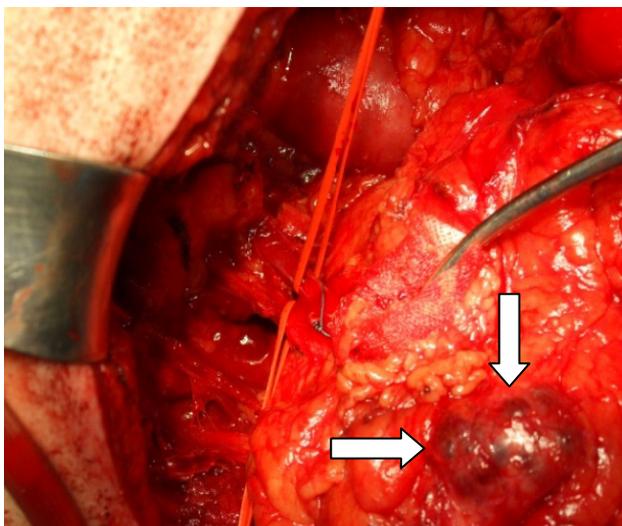
aortic emergence regions. The preparation up to the segmental branches was necessary in order to securely isolate the vascular territory of the tumoral process without passing the oncologic resection margins (Figure 1). The double renal artery was shown intraoperatively in five male patients and two female patients (Figure 2).

In five cases (14.2%), early extrasinusual branches of the renal artery were detected, some having four branches and in two cases, an intrasinusual branch was detected. These cases have impossible conventional surgery access; in consequence, we have clamped in block the renal pedicle and we have used the parenchyma resection and later the hemostasis of the identified vessels.

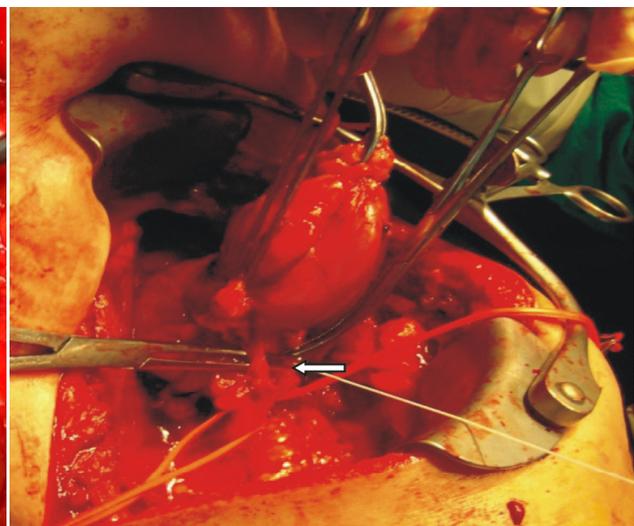
Malformations of the vascular capital were detected in six cases (17.1%). In four of these cases, we found renal veins with separate origins in the vena cava, in one case, we found a double vena cava (Figure 3) and in one case, an absence of the prepyelic vein plane was shown. This last case were treated using robot-assisted transperitoneal approach, while the selective isolation of the various elements of the renal pedicle proved very difficult because of the position of the abdominal aorta between the two vena cava. The tumor was placed near the right kidney (Figure 4) and the right vena cava was in close proximity to the right renal pedicle making it difficult to prepare it. Despite all this, there were no intraoperative incidents and the blood loss was minimal (approximately 150 mL).

In 27 cases (26%) treated for obstruction of the ureteral junction we have detected the directly involved cause: a segmental artery that circled the collecting system in 23 case (Figure 5) and a mixt vicious artery-vein crossing in four other cases (Figure 6).

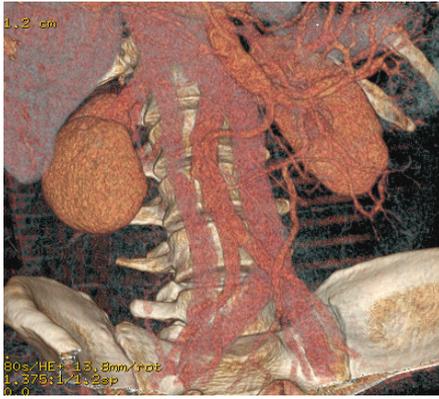
Dismembered pyeloplasty while preserving segmental vessels or the aberrant renal pedicle was applied to each of these patients. There were no significant differences between men and women in terms of vascular anomalies incidence on the right side compared to the left side.



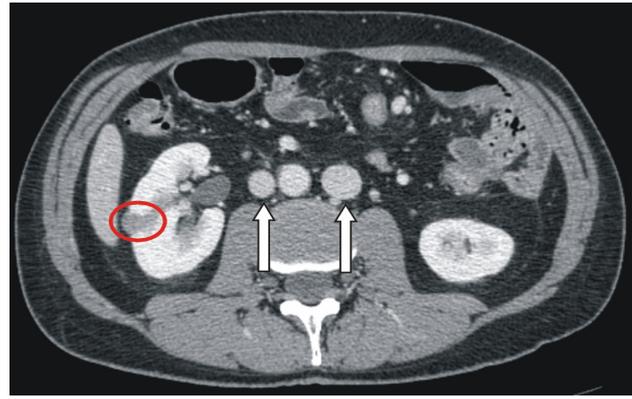
**Figure 1** – Two selectively isolated renal arteries and small renal tumor (arrows).



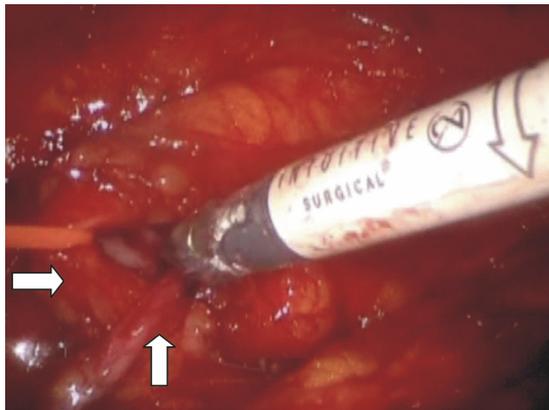
**Figure 2** – Clamping of the renal artery adjacent to the tumor (arrow).



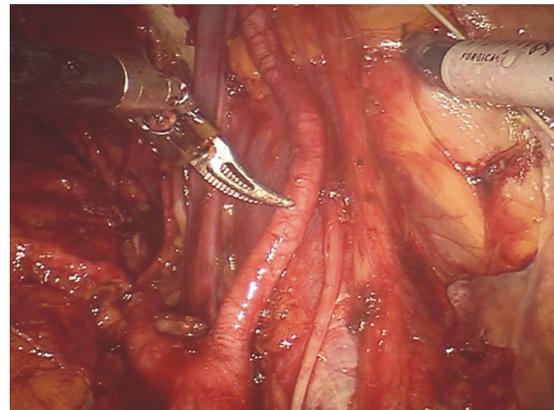
**Figure 3 – Coronal CT reconstruction showing a duplicate abdominal vena cava.**



**Figure 4 – Axial CT a right renal tumor of 14 mm (oval) and the presence of two inferior vena cava (arrows).**



**Figure 5 – Inferior polar artery (up arrow) anterior-crossing the collecting system (right arrow).**



**Figure 6 – Robot-assisted pelvic lymphadenectomy.**

## Discussion

Knowing and surgically exposing the locoregional vascular anatomy are very important to the “nephron sparing” technique as they ensure a lower level of injuries in adjacent territories. The renal pedicle usually consists of two vessels: a renal artery and a renal vein on each side. Anatomical variations of arterial capital were detected in over 57% of the cases, while anomalies of the vein territory were found in 11.4% of the patients included in the study.

According to literature data, multiple renal arteries are found in 25–40% of cases. Out of these, the most frequent occurrence is that of two renal arteries originating in the abdominal region of the aorta. Intra-renal penetration of these arteries and intraparenchymal distribution are very variable. There are cases when an artery penetrate intrahilar and another extrahilar. These are in fact the polar renal arteries (superior and inferior) that usually vascularize a single inferior or superior renal segment.

In the cases of this study, the direction of the posterior branch of the renal artery varied depending on the morphology of the renal pelvis. For an ampullary or fusiform renal pelvis, the posterior arterial branch had a convex direction, side-stepping the renal pelvis. In the “T”-shaped renal pelvis and the branched one, the posterior artery has an oblique direction; thus, the vascular network masks the renal pelvis and renders the surgical approach more difficult.

Two separate planes describe the vein drainage of the kidney: an anterior and prepyelic one and a posterior and retropyelic one. In one of the cases included in our study, we detected the absence of the prepyelic plane.

The double abdominal vena cava is a congenital malformation consisting in the persistence of the embryonic vein system [15, 16]. The incidence of this malformation is very low: 0.2–3% [15]. Majority of cases are clinically inert and are diagnosed incidentally during high-resolution investigations (computer tomography and magnetic resonance). The presence of a double inferior vena cava can be missed or confused with a voluminous adenopathy [17, 18] or a left ureteral dilatation when using conventional radiology [19].

One of the patients included in the study showed two abdominal vena cava making it more difficult to prepare the right renal pedicle, because of very close contact with this vena cava.

Compared to literature data that indicated an incidence of 40% of inferior polar artery of aberrant pedicle involvement in the collecting system obstruction [21], our study group had an incidence of 26%. Because of a terminal type of arterial vascularization the surgical decision to unobstruct the collecting system was taken in favor of ligating and sectioning of the involved vessel. To avoid any further injury that would alter renal function we have performed a standard approach to section and to perform anastomosis on the ureter prior to the aberrant pedicle [11]. Isolating and preparing the vascular capital along with showing vascular variants

offers a greater degree of security and a real vascular skeletisation (Figure 6).

Robot-assisted surgical approach is easier and vascular preparation is more efficient thanks to degrees of liberty and 3D view. Technical challenges specific to robot-assisted laparoscopic partial nephrectomy relate to preparing an a-vascular field for tumoral excision, pyelocaliceal repair and efficient hemostasis in a shorter time in order to preserve renal function [20]. In all surgical specialties, urology is among the first that accepted and implemented minimally invasive therapy in daily routine with maximum benefits for the patients [21].

## ☐ Conclusions

Surgical interventions using “nephron sparing” technique became a golden standard in small renal tumors. Partial nephrectomy and pyeloplasty done by conventional surgery are a current practice of medical centers with no minimally invasive logistic.

In small tumors, partial nephrectomy generates long-term oncologic performances that are similar to those of radical nephrectomies and also preserves renal function.

In the case of unique renal vessels, intraparenchymal distribution usually follows modal typology. Renal segmental resections are usually performed without special technical problems.

Because of the segmental character of renal artery branch distribution, their ligature and sectioning lead to necrosis of the supplied area. In light of this aspect, all accessory renal arteries must be prepared and pinpointed during clamp vascular obstruction. The presence of multiple renal vessels in intraparenchymal distribution requires a better knowledge of locoregional anatomy using complete preoperative evaluation. The minimally invasive approach by robotic laparoscopy remains an essential coordinate in renal surgery and allows an efficient preparing of the vascular capital and a success rate which is comparable to that of conventional surgery.

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