

Robot-Assisted Nephrotomy as a Nephron-Sparing Approach for Completely Intraparenchymal Renal Tumors

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Abstract

Introduction: The diagnosis of small renal masses and the endophytic tumor approach have become challenging. This study aims to describe exclusively robot-assisted surgery as an alternative nephron-sparing approach for renal intraparenchymal tumors. **Patients and Methods:** We retrospectively analyzed all patients with completely endophytic tumors undergoing robot-assisted partial nephrectomy, treated under the Da Vinci System®, aided by intraoperative ultrasound. The patients' demographic characteristics, perioperative and oncological outcomes were assessed. **Results:** From a total of 13 partial nephrectomies performed between 06/2010 and 10/2021, all patients underwent nephrotomy. The patients' mean age was 52 years and the tumor measured mean 2.6 cm. Warm ischemia time was 24 minutes and histopathological analysis revealed that 12 patients had renal cell carcinoma. In a mean 36-month follow-up, no significant renal function alterations were found and no local or systemic recurrences occurred. **Conclusion:** Robot-assisted access is a safe and effective option for the nephron-sparing technique in completely intraparenchymal renal tumors.

Keywords

Robotic Surgical Procedures, Kidney Neoplasms, Organ Sparing Treatment, Nephrectomy, Renal Mass

1. Introduction

With the development of image diagnosis techniques and the larger number of exams requested, the incidence of small renal tumors has increased as well as the

indication for nephron-sparing surgery, with excellent oncological and functional outcomes [1]. Incidental lesions account for more than 60% of the renal tumors detected [2].

Partial nephrectomy is being increasingly used for small renal masses (<4 cm) and, in selected cases, up to 7 cm renal tumors, with similar outcomes compared to radical nephrectomy [3] [4] [5].

Completely intraparenchymal renal tumors imply greater technical difficulties for location and resection, which may increase the chances for complications [6]. The exact location of the tumor during surgical resection is provided by intra-operative ultrasonography [7].

Currently, despite the group's experience in open partial nephrectomy, including removal of intraparenchymal tumors [8], there is a natural transition towards minimally invasive techniques [9], the robotic one in particular [10] (Figure 1).

This study aims to present a robot-assisted surgical approach for the removal of completely intraparenchymal renal tumors.

2. Materials and Methods

We retrospectively analyzed 13 patients undergoing RAPN, all with completely endophytic tumors. Patient demographics, perioperative, functional and oncological outcomes were assessed. All patients underwent RAPN between August/2016 and July/2021 by a single senior surgeon (MFD), with large previous experience in open partial nephrectomy, including cases of intraparenchymal tumors. This retrospective study had been approved by Institutional Ethical Committee, the formal consent was not required because the images are anonymous from which the individual cannot be identified.



Figure 1. ((A) and (B)) Patient position; (C) Change of position; (D) robotic docking.

The detailed surgical technique is described below:

- 1) The transperitoneal approach for RAPN was followed in all cases.
- 2) Access was gained through four robotic trocar positions, the kidney was dissected and exposed, and the renal artery was clamped;
- 3) Ultrasound was used to identify the tumor margins and depth. Before the renal hilum was clamped, 12.5 g and 20% manitol was administered for nephron protection during warm ischemia.
- 4) Shortly after the renal artery was clamped with a bulldog clamp, nephrotomy was performed on a marked area aided by the US. Tumor enucleation was then performed by using a bipolar fenestrated grasper and a blunt and sharp dissection Scissor.

The surgical specimen was promptly forwarded for histopathological analysis of the margins during renal reconstruction (**Figure 2**). Hemostasis was done with 2.0 v-lock parenchymal suture. The kidney was then sutured using Vicryl 0 running suture;

- 5) In all cases a suction drain was placed around the gerota fascia.

3. Results

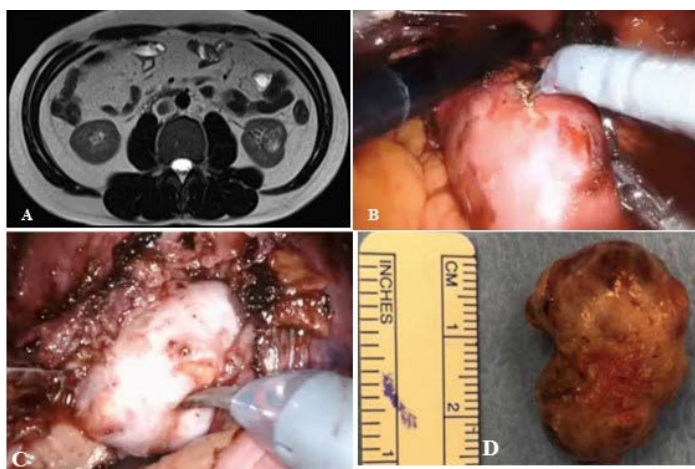


Figure 2. A 44-year-old patient with a left side 2.6-cm interpoler completely endophytic renal mass (R.E.N.A.L. nephrometry score 10×). RAPN was performed without perioperative complications, with a WIT of 25 min. Pathology showed renal cell carcinoma (RCC), clear cell type, Fuhrman nuclear grade 2, and margins coincident with the tumor (tumor enucleation). (A) CT transverse section; (B) use of intraoperative US and appointment for nephrotomy; (C) enucleated tumor; (D) surgical piece.

In a total of thirteen patients assessed, the mean age was 52 years, all being males. The mean tumor size was 2.6 cm, with a mean 24 min warm ischemia time. Mean preoperative serum creatinine was 0.9 mg/dl and the postoperative value was 1.0 mg/dl (**Table 1** and **Table 2**).

Histopathological analysis showed only one lesion of benign etiology, and among the renal cell carcinomas, eight were clear cells and four were papillary (**Table 3**). Most were low Fuhrman grade lesions and no positive surgical margins were found in this series (**Table 4** and **Table 5**).

Table 1. Demographic data.

Variables	Mean (min - max)
Age (years)	52 (30 - 59)
Gender	
Male	13 (100%)
Tumor side	
Left	8 (61.5%)
Right	5 (38.5%)
Tumor size (cm)	2.6 (0.6 - 4.5)
Tumor location	
Upper	2
Middle	7
Lower	4
R.E.N.A.L Score	
Low	1
Intermediary	11
High	1

Table 2. Perioperative results.

Variables	Mean (min - max)
Operative time (min)	150
Warm ischemia time (min)	24 (15 - 45)
Negative margins	100%
Conversion to radical Nephrectomy	0
Trifecta	69%
Hospital stays time (days)	3

Table 3. Pathological data.

Variables	Mean or number
Malignant histology	12 (92.5%)
Clear cells	8 (66.5%)
Papillary	4 (33.5%)
Furhmann Grade	
1	4
2	4
3	4

Continued

Negative margins	100%
Angio-lymphatic invasion	0
Benign tumors	1 (7.5%)

Table 4. Demographic data, tumor characteristics, and warm ischemia time.

Patient	Gender	Age (years)	Tumor size (cm)	Tumor location	Warm ischemia time (min)
1	M	41	0.6	Upper	15
2	M	69	0.9	Lower	24
3	M	46	0.8	Lower	21
4	M	68	2.5	Middle	44
5	M	38	2.4	Middle	23
6	M	34	4.5	Middle	45
7	M	69	4.5	Middle	21
8	M	52	2.2	Lower	20
9	M	76	2.7	Upper	32
10	M	45	2.7	Middle	25
11	M	63	4.1	Middle	25
12	M	63	3.2	Lower	17
13	M	44	2.6	Middle	27
Mean		52	2.6		24

Table 5. Pathological characteristics of the renal tumor.

Patient	Histology	Fuhrman Grade	Vascular invasion	Preoperative Cr (mg/ml)	Postoperative Cr (mg/ml)
1	Papillary	I	No	0.9	1.0
2	Papillary	I	No	0.9	1.1
3	Complex cyst	-	No	0.9	0.96
4	Clear cells	III	No	3.3	3.7
5	Papillary	I	No	1.0	1.01
6	Clear cells	II	No	1.1	1.3
7	Papillary	I	No	1.4	1.6
8	Clear cells	III	No	0.8	0.9
9	Clear cells	II	No	0.99	1.1
10	Clear cells	II	No	0.98	0.97

Continued

11	Clear cells	III	No	0.6	0.7
12	Clear cells	III	No	0.9	0.9
13	Clear cells	II	No	0.8	0.9
Mean				0.9	1.0

None of the patients had significant intraoperative bleeding, required any blood transfusion or evolved to fistulae or urinary collections in the postoperative. None of the patients undergoing the surgery had any renal function unit loss.

All the patients were monitored under the same protocol during a mean 36-month (6 - 72) follow-up, and no local recurrence or systemic diseases were observed.

4. Discussion

Robotic nephrotomy in the handling of solid and completely endophytic tumors represents a definitive and reliable approach, preserving renal function in all cases, besides providing a better exposure and safety for tumor resection. The robotic surgery advantages and the growing experience in nephron-sparing minimally invasive surgeries enable experienced surgeons to perform RPN in challenging cases [11].

Rogers *et al.* [12] were the first to show the feasibility and safety of RAPN in twelve complex cases, including hilar, endophytic, and/or multiple tumors. The mean size of the tumor was 3.6 cm, with 192 min mean operative time and 31 min WIT. All patients had negative surgical margins. Later, Gong *et al.* [13] reported the results of 29 patients undergoing RAPN for renal mass, including hilar, endophytic, and multiple tumors. The mean size of the tumor was 3 cm, with 197 min mean operative time and 25 min WIT. All cases had negative surgical margins and no recurrence was found in the mean 15 months follow-up.

Compared to such historical series, our findings suggest excellent RAPN performance for completely endophytic masses. Our group reported the consecutive experience in 13 cases, with mean 2.6 cm tumor size, mean 150 min operative time, and 24 min WIT. A small rate of intraoperative complications was evidenced, all surgical margins were negative, and no recurrence was found after a 36-month follow-up.

Besides, the achievement of a “Trifecta” that stands for a parameter introduced to define the quality of the RAPN procedure [14], in 69% of the endophytic tumors, shows a favorable outcome compared to other minimally invasive PN series reported [15] [16].

Partial nephrectomy and/or enucleation account for 30% of the surgical procedures in the treatment of renal tumors, with survival similar to the one found in radical nephrectomy for the early stages, evidencing a cancer-specific and overall survival of 98% and 97%, respectively [1] [4]. For <4 cm tumors, no ad-

ditional surgical margin needs to be removed for ideal cancer control. The study reaffirmed the relevance of the healthy parenchyma thickness excised along with the tumor for long-term renal function preservation. Simmons *et al.* [17] showed the percentage of renal volume preservation rather than WIT to be the main determinant of the final eGFR following PN, and that the technical changes designed to minimize healthy volume loss, while still reaching negative margins, may account for a better functional outcome.

There are many definitions of central tumors, the best accepted of which are those of Black *et al.* [18], when the lesion is fully surrounded by normal renal tissue, and that of Brown *et al.* [19], when the lesion is less than 5 mm distant from the excretory system or hilar vessels. A rather challenging scenario is represented by such completely intraparenchymal renal masses, considering that the surgeon has no visual clues of the tumor location as the kidney surface is reached. Thus, surgical removal of those lesions encompassed greater technical difficulties for location and resection, besides a greater probability of perioperative complications. If well-succeeded perioperative and oncological outcomes are to be achieved, we strongly suggest that intraoperative ultrasound be used for identification of tumor margins, as advocated by Assimos *et al.* [20]. It can be controlled robotically or laparoscopically by the bedside assistant.

The use of minimally invasive ablative therapies, such as radiofrequency and cryotherapy for small renal tumors, is currently on the rise, providing greater safety and broadening their indications [21]. However, since the tumor is endophytic and close to the excretory path and hilar vessels, this approach may be a limiting factor [22]. A nephron sparing surgery for central tumors has shown to be safe and effective compared to peripheral tumors, evidencing that operative and ischemia time, the need to close the collector system and blood transfusion showed no statically significant differences. Autorino *et al.* [23] reported their experience in the robotic management of renal mass, comparing the results of endophytic masses with mesophytic and exophytic tumors and stated that they found no differences in terms of surgical complications, positive margins rate or postoperative changes in eGFR.

The limitations of this study involve its retrospective nature despite the prospective data collection, the small number of patients, 36-month median follow-up, and absence of studies of the renal function of the units treated, or of serum creatinine. Nevertheless, the lesions were safely enucleated, providing negative margins and an acceptable warm ischemia time.

As a positive point, it seeks to encourage that the robotic approach be performed, even by surgeons with small or no experience at all in laparoscopic surgery.

5. Conclusion

RAPN can be performed safely and effectively for endophytic renal tumors. The accurate use of laparoscopic US and the exclusive robotic surgery platform resources facilitate the procedure in this challenging scenario.

Data Availability Statement

The data are stored in the electronic medical record system of the Hospital.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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