Actas Urol Esp. 2012;36(1):15–20

Actas Urológicas Españolas

www.elsevier.es/actasuro

ORIGINAL ARTICLE

Robotic partial nephrectomy: An initial experience in 25 consecutive cases☆

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Received 24 May 2011; accepted 5 June 2011
Available online 17 March 2012

KEYWORDS
Partial nephrectomy;
Robotic surgery;
Nephron-sparing surgery;
Renal tumor

Abstract

Objective: To report our initial experience with robotic partial nephrectomy (RPN) in a series of 25 consecutively operated patients.

Material and methods: A series of 25 consecutive patients who underwent RPN from April 2010 to February 2011 were studied. We used the da Vinci S HD robotic system with transperitoneal approach. Total renal hilum control was used for 22 cases and 3 patients underwent selective renal parenchymal compression with an ad hoc device.

Results: Mean age was 55.8 years (26–77) with a male/female ratio of 2:1. Mean operative time was 117.6 min (54–205) and the warm ischemia time was 20.2 min (9–34). Mean estimated blood loss was 440 ml (20–2000) and the mean tumor size was 3.25 cm (1–5.3). Five patients (20%) had complications, the most frequent being intraoperative bleeding (Clavien II). There was no conversion to open or laparoscopic surgery. Mean hospital stay was 3.5 days (1–7). The pathological study revealed renal cell carcinoma in 19 cases and benign lesions in 6 patients. There were no positive surgical margins and no mortality.

Conclusions: Our preliminary results show that RPN is a feasible surgical approach in small-sized renal tumors.

PALABRAS CLAVE
Nefrectomía parcial;
Cirugía robótica;
Cirugía conservadora de nefronas;
Tumor renal

Nefrectomía parcial robótica: experiencia inicial en 25 casos consecutivos

Resumen

Objetivo: Presentar nuestra experiencia inicial en nefrectomía parcial robótica (NPR) en una serie de 25 pacientes operados de forma consecutiva.

Material y métodos: Se trata de una serie de 25 pacientes consecutivos sometidos a NPR desde abril de 2010 a febrero de 2011. Se utilizó el sistema robótico da Vinci S HD, con abordaje transperitoneal. En 22 casos se utilizó control vascular total del hilio renal y en tres casos se realizó compresión selectiva del parénquima renal con un dispositivo ad hoc.

☆ Please cite this article as: Castillo OA, et al. Nefrectomía parcial robótica: experiencia inicial en 25 casos. Actas Urol Esp. 2012;36:15–20.

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2173-5786/$ – see front matter

Resultados: La edad promedio fue de 55,8 años (26-77), con una relación hombre/mujer 2:1. El tiempo operatorio promedio fue de 117,6 minutos (54-205) y el tiempo de isquemia caliente fue de 20,2 minutos (9-34). El sangrado estimado promedio fue de 440 ml (20-2.000). El tamaño tumoral promedio fue de 3,25 cm (1-5,3). Cinco pacientes (20%) presentaron complicaciones, siendo la hemorragia intraoperatoria la más frecuente (Clavien II). No hubo conversión a cirugía abierta o laparoscópica. La estancia media hospitalaria fue de 3,5 días (1-7). El examen patológico de las lesiones reveló carcinoma renal en 19 casos y lesiones benignas en 6 pacientes. No hubo márgenes quirúrgicos positivos ni mortalidad.
Conclusiones: Nuestros resultados preliminares muestran que la NPR es una alternativa quirúrgica factible de realizar en pacientes con tumores renales de pequeño tamaño.

Introduction

The incidental finding of renal tumors smaller than 4 cm has resulted from the frequent application of imaging in the study of non-specific abdominal symptoms. This change has resulted in a migration of the diagnosis to renal tumors of smaller size and better nuclear differentiation, subject to conservative renal surgery.[1] Their surgical indication, then, has evolved from the imperative indication in patients with solitary kidneys to the relative indication in patients with renal pathology or risk of decline in glomerular filtration, and to elective surgery in patients with normal contralateral kidney.

Laparoscopic partial nephrectomy (LPN) was initially applied to tumor lesions smaller than 4 cm, of favorable anatomical location (T1a), expanding then to tumors of technically more complex location and larger lesions (T1b).[2–4] However, laparoscopic surgery is technically difficult, requires a long learning curve, and it is not exempt from serious complications. The analysis of the medical literature still shows an underutilization of LPN in the treatment of renal tumor lesions in T1a and T1b stages.[5] Since its introduction in 2004, robot-assisted partial nephrectomy (RPN), using the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA), has gained slow acceptance as an alternative to open partial nephrectomy (OPN) and laparoscopic for patients with small renal masses subject to conservative surgery.[6] The aim of this article is to analyze the initial surgical and clinicopathological results of our first 25 cases of RPN.

Material and methods

Between April 2010 and February 2011, 25 patients with renal tumor diagnosis were operated consecutively in our center. The series consisted of 17 men and 8 women, with a mean age of 55.8 years (range: 26–77 years) and mean body mass index of 27.1 kg/m^2 (range: 22–32). We used the da Vinci S HD robotic system (Intuitive Surgical, Sunnyvale, CA, USA), and all the surgeries were performed by only one surgeon (O.A.C.). The data were collected prospectively and analyzed retrospectively. Preoperative evaluation included computed tomography and/or MRI, with reconstruction of the vascular phase. We studied the tumor location, size, clinical stage, surgical time, ischemia time, pathological stage, and surgical margins. We defined the complications of the procedure using the modified Clavien classification.[7]

Surgical technique

Transperitoneal approach was used in all cases. The patient is placed in lateral decubitus position with flexion and fastened to the operating table, with protection of pressure areas (Fig. 1). A Veress needle pneumoperitoneum is performed classically. In all the procedures, a technique with 3 or 4 robotic arms (Figs. 2 and 3) and 30° optics was performed, using additional trocars for the assistant. The renal hilum is dissected identifying the vein and artery, which are marked with an elastic vessel. When total vascular control is required (artery and vein), 0.5 g/kg mannitol is administered intravenously prior to the clamping of the renal pedicle. For this, we use either laparoscopic bulldog clamps (Aesculap®), Rummel tourniquets,[8] or laparoscopic Satinski clamps (Storz®), at the surgeon's discretion. In polar tumors, we have used selective compression of the renal parenchyma (Simon Renal Pole Clamp, Aesculap, Inc., Center Valley, PA). The tumor is resected with cold scissors to better visualize the limit of the normal renal parenchyma. Renal reconstruction is performed with 3-0 Monocryl® continuous suture at the calyceal-vascular level, and a second level of parenchyma with interrupted sutures of 2-0 Vicryl® in CT-1 needle, with the sliding Hem-O-lok® clip technique described by Benway et al.[9] We do not perform intraoperative frozen biopsy.

Results

The perioperative data are summarized in Table 1. The mean surgical time, from the initial incision to the skin closure, was 117.6 min (range: 54–205 min). We used total control of the renal hilum in 22 patients, with a mean warm ischemia time of 20.2 min (range: 9–34 min), and renal parenchymal compression was performed, without transient vascular occlusion in three patients with polar tumors. The estimated bleeding was 440 ml (range: 20–2000 ml).

There were 5 perioperative complications (20%). In 4 patients, there was intraoperative bleeding (Clavien II) in the resection of the tumor. In all these cases, inadequate

Figure 1 Patient positioning for left robotic partial nephrectomy.

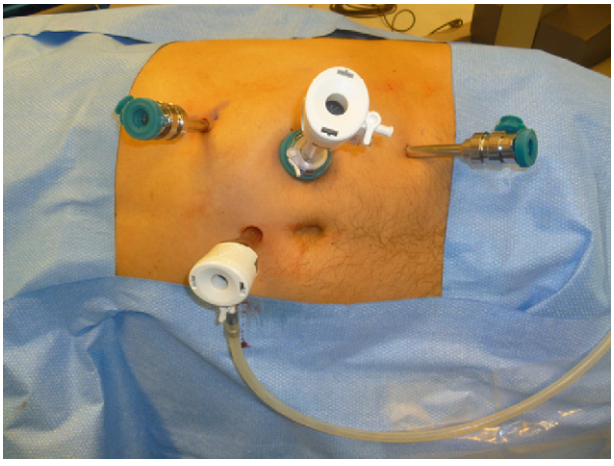

Figure 2 Trocar placement in 3-arm technique.

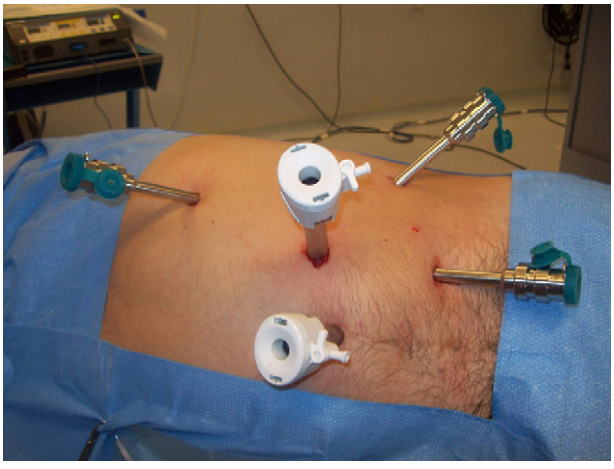

Figure 3 Trocar placement in 4-arm technique.

Table 1 Demographic characteristics of the patients.

Male/female	17/8
Age (years)	55.8 (26–77)
Body mass index	27.1 (32–22)
ASA	1.6 (1–3)
Side (right/left)	12/13
Tumor location	
Upper pole	10
Medium pole	8
Lower pole	7

Table 2 Pathological findings in our series.

Tumor origin	
Malignant (%)	19 (76%)
Clear cell carcinoma	18 (72%)
Chromophobe carcinoma	1 (4%)
Benign (%)	6 (24%)
Oncocytoma	1 (4%)
Angiomyolipoma	2 (8%)
Simple cyst	1 (4%)
Hemorrhagic cyst	2 (8%)
Pathological stage (%)	19 (100%)
T1a	18 (94.7%)
T1b	1 (5.3%)
Pathological grade	
Fürhman's grade I	1 (5.3%)
Fürhman's grade II	10 (52.6%)
Fürhman's grade III	8 (42.1%)
Positive surgical margins	0

Figure 4 Renal tumor with a good margin of normal parenchyma is observed.

vascular control of the renal hilum was identified: in two cases, there was an accidental displacement of the bulldog clamp and there was inadequate Hem-o-lok® clip placement on Rummel's elastic loop in the other two. None of these cases required conversion to open surgery or need for nephrectomy. Another patient had a massive hemoperitoneum 12 h after surgery, requiring emergency exploratory laparotomy for hemostasis and kidney repair, without need for nephrectomy and evolving without further incidents (Clavien IV).

The average tumor size was 3.6 cm (1–11.5 cm). Three lesions were larger than 7 cm: an angiomyolipoma of 11.5 cm and two complex renal cysts of 8 and 10 cm. Pathologic examination of the lesions revealed renal carcinoma in 19 cases (76%) and benign lesions in 6 patients (24%) (Table 2). There were no positive surgical margins (Fig. 4).

Table 3 RPN published series.

	Institution	RPN (*n*)	Tumor size (cm)	TS time (min)	WIT (min)	EBS (ml)	HS (d)	Complications (Clavien grade)	Positive margin (*n*)	Urinary loss (*n*)	Conversion
Gettman et al.[6]	Mayo Clinic	13	3.5	215	22	170	4.3	None	1	NR	0
Kaul et al.[16]	Henry Ford	10	2	155	21	92	3.5	II:1 III:1	1	1	0
Caruso et al.[17]	New York University	10	1.95	279	26.4	240	2.6	III:1	0	NR	1 a NPA 1 a NPL
Rogers et al.[18]	National Institutes of Health	8	3.6	192	31	230	2.3	None	0	NR	NPR
Aron et al.[19]	Cleveland Clinic	12	2.4	242	23	329	4.7	II:2 III:1	0	0	2 a NPL
Deane et al.[20]	UC Irvine	11	2.3	229	32.1	115	2.0	III:1	0	NR	0
Ho et al.[21]	Medical University Innsbruck, Austria	20	3.5	82.8	21.7	189	4.8	None	0	0	0
Wang et al.[22]	Washington University	40	2.5	140	19	136	2.5	II:2 III:1 Unreported: 4	1	1	1 a NPA 1 a Cryoablation
Michli et al.[23]	Cooper University Hospital	20	2.7	142	28	263	2.8	II:1 III:1	0	NR	1 a NPA
Gong et al.[24]	City of Hope	29	3.0	197	25	220	2.5	UR	0	NR	NR
Benway et al.[10]	Multiple institutions	129	2.9	189	19.7	155	2.4	II:1 III:4 Unreported: 6	5	3	2 a NPA
Scoll et al.[25]	Fox Chase Cancer Center	100	2.8	206	25.5	127	3.2	II:5 III:5 V:1	5	2	1 a NPA 1 a NRA
Haber et al.[26]	Cleveland Clinic	75	2.75	200	18.2	323	4.2	II:7 III:2	0	1	3 a NPL
Benway et al.[15]	Multiple institutions	183	2.87	210	23.9	131.5	UR	Unreported: 18	7	2	2 a NPA
Current series	Clínica Indisa	25	3.66	117.6	20.2	440	3.5	II: 4 IV:1	0	0	0

HS: hospital stay; RPN: robotic partial nephrectomy; UR: unreported data; EBS: estimated blood loss; TS: total surgical; WIT: warm ischemia time.

The average hospital stay was 3.5 days (range: 1–7 days), excluding the patient who required exploratory laparotomy.

Discussion

Surgery for kidney cancer has undergone an important evolution with the use of laparoscopic approach in the treatment of stage T1 tumors. Today, lesions of 7 cm or smaller are treated conservatively with adequate oncological results, while renal parenchyma is preserved and morbidity decreases.[10,11] In a comparative study of 1800 partial nephrectomies, 771 LPN vs 1029 OPN, there was a significant decrease in estimated blood loss (300 ml vs 376 ml), in hospital stay (3.3 days vs 5.8 days), and total surgical time (201 min vs 226 min). However, there was longer warm ischemia time (30.7 min vs 20.1 min) and higher incidence of postoperative complications (24.9% vs 19.2%). Cancer-specific survival at 3 years was similar: 99.3% for LPN vs 99.2% for OPN.[11]

A study by the *Clínica Universidad de Navarra* describes a series of 30 LPN with a mean surgical time of 214.4 min, warm ischemia time of 31.3 min, and estimated bleeding of 74.6 ml. Positive surgical margins were obtained in three cases, being converted to open surgery.[12]

The LPN is technically difficult, with a long learning curve, which explains why the traditional open surgery is still dominant on LPN in the treatment of stage T1 renal lesions.[5] The da Vinci robotic system was introduced in urological practice in the hope of reducing the gap between advanced laparoscopic surgery and open surgery. The first study on the feasibility of robotic partial nephrectomy (RPN) was conducted at the Mayo clinic, experience published by Gettman et al. in 2004. Thirteen carefully selected patients, with small exophytic renal tumors (average size of 3.5 cm), underwent RPN. The mean operative time was 215 min, the warm ischemia time 22 min, the average bleeding 170 ml, and there was a case with positive surgical margin (7.7%).[6]

A recent article reviews 3622 urological surgeries conducted by the *Fundación Puigvert* over a period of 10 years, performing an analysis of the evolution of open to laparoscopic/robotic surgery. Excluding endoscopic surgery, they found 67.75% open, 26.17% laparoscopic, 2.29% perineal, and 3.78% robotic surgeries. They observed an increase of the laparoscopic approach over the last 12 months compared to the first 9 years of follow-up; in partial nephrectomies, it increased from 31.3 to 87%, comparing open with laparoscopic surgery, but in this study, no mention is made about robotic surgery.[13]

The only study with larger number of cases corresponds to a multi-institutional comparative work between RPN and LPN performed consecutively (129 RPN and 118 LPN), reported by Benway et al.[10] This review shows a reduced warm ischemia time (19.7 min vs 28.4 min), decreased estimated blood loss (155 ml vs 196 ml), and length of hospital stay (2.4 days vs 2.7 days) for RPN, being statistically significant even when it is a type 2 evidence.

In a multi-institutional study, Rogers et al. confirmed the safety and feasibility of RPN in 148 patients, with results comparable to those obtained with OPN and LPN.[14] To date, the largest multi-institutional experience with RPN has recently been reported by Benway et al., who described the functional and oncological outcomes in 183 patients. The mean surgical time was 210 min, the warm ischemia time 23.9 min, and the positive margin rate was 2.7%.[15]

In an analysis of 147 consecutive LPNs conducted by a single surgeon, Castillo et al. emphasize that the considerations that must be made in relation to LPN have to do with the possible complications related to the procedure. This surgery incorporates a delicate treatment of control of the renal pedicle, which is essential to obtain the renal ischemia required during tumor resection. This step represents the first vascular phase of the operation. Once the tumor is resected, the second vascular phase of the procedure is started, which corresponds to the renal parenchymal hemostatic closure, which must also ensure a secure closure of the pelvicalyceal system, often affected during resections in search of oncological safety margins.[3] In our series, complications were secondary to poor control of the renal pedicle in 4 cases, resulting in a mean blood loss of 1750 ml (1500–2000 ml). So, it was observed that the arterial clamp had been released (accidental displacement of the bulldog clamp in two cases, and inadequate placement of the Hemo-lok® clip on Rummel's elastic loop in the other two), which determined poor ischemia during the tumor resection, even when conversion was not necessary.

Table 3 summarizes a comprehensive review of the literature with 14 series of RPN ($n = 660$), in which an average surgical time of 191 min, average warm ischemia time of 24 min, average estimated blood loss of 194 ml, and hospital stay of 3.2 days[6,10,15–26] are shown. Compared to the average of the mentioned series, we observed that in ours, the average total surgical time was shorter (117.6 min), as well as the warm ischemia time (20.2 min), even when the estimated bleeding was higher (440 ml).

The RPN has become a minimally invasive alternative of conservative surgery with good oncological outcomes. We practiced 25 RPNs with results comparable to previous studies, and very similar to those obtained with OPN and LPN. Based on our experience, RPN is currently our technique of choice for minimally invasive conservative treatment of renal tumors.

Conclusions

We present the first series of RPN in Spanish literature. Our preliminary results show that RPN is a viable alternative in the minimally invasive conservative management for patients with renal tumors.

Conflict of interest

The authors declare that they have no conflict of interest.

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