

Article

Laparoscopic versus Robot-Assisted Partial Nephrectomy for Renal Tumors with Cystic Features: Comparison of Perioperative Outcomes and Trifecta Achievement

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Abstract: **Background:** To compare perioperative outcomes and trifecta rates between laparoscopic and robotic partial nephrectomies (PN) using the Hugo™ RAS System, a study was conducted between October 2022 and September 2023. **Methods:** Twenty-two patients underwent minimally invasive PN for cystic renal tumors at our institution (group A: RAPN = 6; group B: Laparoscopic PN = 16). The trifecta was defined as the coexistence of negative surgical margin status, no Clavien–Dindo grade ≥ 3 complications, and eGFR decline $\leq 30\%$. Continuous variables were presented as median and IQR and compared using the Mann–Whitney U test, while categorical variables were presented as frequencies (%) and compared using the χ^2 test. For all statistical analysis, a two-sided p -value < 0.05 was considered statistically significant. **Results:** All patients successfully underwent off-clamp minimally invasive PN without the need for conversion or additional port placement. Group A showed a lower preoperative eGFR rate and a higher clinical tumor size, while group B displayed a higher number of male patients and bilateral lesions. However, these differences were not statistically significant (all $p > 0.1$). Regarding perioperative data, group A showed a lower operative time (79.5 vs. 134.5 min, $p = 0.01$), while group B showed a higher trend of benign histology (62.5% vs. 33.3%). All the other perioperative data were comparable between the two groups (all $p > 0.2$). The rate of trifecta achievement was 83.3% and 87.5% ($p = 0.80$) for group A and B, respectively. **Conclusion:** This study emphasizes the advantages of RAPN over laparoscopic procedures in terms of operative time. Extensive experience in Laparoscopic PN could be a key factor when approaching RAPN learning curve.

Keywords: cystic renal masses; Hugo RAS; minimally invasive; partial nephrectomy; robotic surgery



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1. Introduction

Renal cell carcinoma (RCC) is the 14th most common cancer globally, with rising incidence due to advancements in radiology, particularly ultrasounds (US), computed tomography (CT) scans, and magnetic resonance imaging (MRI) that have increased detection of incidentalomas and small renal masses (SRMs) under 4 cm. Management of SRMs includes active surveillance, ablation therapy, and surgery. Nephron-sparing surgery (NSS), like partial nephrectomy (PN), is recommended when feasible, but SRMs are typically low-grade, slow-growing tumors with low metastatic potential. Ablative techniques, which can be low-temperature (cryoablation) or high-temperature (radiofrequency ablation, microwave ablation), or nonthermal (irreversible electroporation), offer alternatives to surgery, especially for elderly patients with comorbidities or pre-existing renal conditions [1].

However, PN is the preferred surgical treatment for T1 (tumour ≤ 7 cm or less in greatest dimension, limited to the kidney; T1a ≤ 4 cm; T1b > 4 cm but ≤ 7 cm) RCC and should be considered for T2 tumors (tumour ≥ 7 cm or less in greatest dimension, limited to the kidney; T2a > 7 cm but ≤ 10 cm, T2b > 10 cm) whenever technically feasible in specific cases as patients with a solitary kidney, bilateral tumors, or chronic kidney disease with enough residual parenchymal volume to provide adequate function after surgery [2–6]. This approach also offers similar oncological outcomes and fewer long-term cardiovascular and metabolic events compared to radical nephrectomy (RN) [7–9]. Additionally, the increasing experience with robot-assisted surgery has gradually enabled the treatment of larger and more complex renal masses, fostering the perception that robotic technology can expand the indications for minimally invasive PN [10].

While the technical complexity of PN poses a primary drawback, leading to an elevated risk of complications, the widespread adoption of robotic systems has contributed to improved surgical outcomes [11]. Indeed, several studies suggest that robot-assisted partial nephrectomy (RAPN) has an easier learning curve compared to laparoscopic partial nephrectomy (LPN) even in surgeons without previous laparoscopic training. Shorter operating time, reduced blood loss, and shorter warm ischemia time (WIT), as well as better preservation of residual renal function, are acknowledged benefits of the robot-assisted approach [12–15].

In the context of PN, cystic renal tumors present challenges in surgery due to the risk of cystic wall rupture during tumor resection, potentially leading to local tumor spillage with the theoretical risk of tumor recurrence. This could represent the reason why many surgeons would avoid a minimally invasive approach instead of traditional open surgery. Anyway, there is scarcity of evidence regarding the risk of tumor recurrence after cyst wall rupture. The existing literature on RAPN for cystic renal masses is very limited and studies comparing the robotic and laparoscopic approaches are currently lacking [16].

The Da Vinci platform has been a pioneer in robot-assisted surgery and, despite the functional advancement brought to the surgical landscape, it inherits some limitations as high running costs and overall dimensions leading to low adaptability and handiness. These intrinsic limitations paved the way for the development of new robotic platforms to reduce procedural costs and to easily adapt to the surgical environment. The novel Hugo™ RAS System, developed by Medtronic (Minneapolis, MN, USA), offers a modular robotic solution comprising a console, system tower, and four independent arm-carts. This design allows for customized surgical approaches tailored to specific procedural needs. Notable technical advantages include improved trocar positioning, expanded workspace for bedside assistants, and cost-effectiveness for individual procedures. Furthermore, the modular nature of the Hugo™ RAS system allows for adaptation to various surgical procedures [17–19].

On this background, the aim of the present study is to report and compare perioperative outcomes of laparoscopic and robotic PN with the Hugo™ RAS System and to evaluate the impact of cystic features on trifecta achievement.

2. Materials and Methods

2.1. Patient Population

The study was approved by the internal Institutional Review Board Statement and Ethics Committee. From a review board-approved prospectively collected database, we retrospectively evaluated twenty-two consecutive patients who underwent minimally invasive PN for cystic renal tumors at our institution between October 2022 and September 2023. These patients were divided into two groups: group A comprised six patients who underwent RAPN using the Hugo™ RAS system, while group B consisted of sixteen patients who underwent traditional LPN (group A, RAPN = 6; group B, LPN = 16).

All study participants gave written informed consent. Baseline and perioperative data were systematically collected. Pre-operative urine culture and computed tomography (CT) scans were done in all patients, with renal masses classified using the R.E.N.A.L. score.

2.2. Endpoints, Data and Statistical Analysis

The primary endpoint of this study was to report perioperative outcomes of minimally invasive PN performed for cystic renal masses and evaluate the feasibility and safety of laparoscopic and robotic approaches. The secondary endpoint was to compare perioperative outcomes between the two aforementioned minimally invasive techniques. Finally, we aimed to evaluate the impact of cystic tumor features on the trifecta achievement rate. Post-operative complications were classified using the Clavien–Dindo system [20]. Body mass index (BMI) was determined by dividing weight in kilograms by height in meters squared (kg/m^2), and eGFR was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula. The trifecta criteria included negative surgical margins, no Clavien–Dindo grade ≥ 3 complications, and an eGFR decline of $\leq 30\%$. Continuous variables were presented as medians with interquartile ranges (IQR) and compared using the Mann–Whitney U test, while categorical variables were expressed as frequencies (%) and compared using the χ^2 test. A two-sided p -value < 0.05 was considered statistically significant for all analyses. Statistical analysis was performed using STATA (StataCorp. 2021. Stata Statistical Software: Release 17. College Station, TX, USA: StataCorp LLC).

2.3. Trocar Placement, Docking System and Surgical Procedure

We utilized an adapted extended flank position by placing the patient at the edge of the surgical bed and employing a moderate 45° flexion to create more space between the same side iliac spine and the rib margin. The initial robotic trocar (11 mm, endoscope port) was inserted transperitoneally along the pararectal line, approximately 14 cm below the xiphopubic line. Up to three additional 8 mm robotic ports were then positioned at least 8 cm laterally from the camera port, ensuring a 2 cm safety margin from any bony prominences. Two additional 12 mm laparoscopic ports for the bedside assistant were placed medially, about 8 cm from the robotic ports to prevent interference with the robotic instruments. The bedside assistant's position, whether standing or seated, varied based on the patient's anatomy, the height of the surgical bed, and the angles of the robotic arm, docking, and tilt. The lead surgeon was seated to effectively control the Hugo™ RAS controllers.

The Air-Seal™ system (SurgiQuest, Milford, CT, USA) was employed to induce pneumoperitoneum, maintaining a standard intra-abdominal pressure of 12 mmHg. The recommended trocar configuration for the Hugo™ RAS system typically includes four robotic arms, consisting of an 11 mm optic port and three 8 mm robotic instrument ports, allowing space for a single laparoscopic trocar for the bedside assistant. In our surgical setup, however, we utilized three to four robotic arms with a three-instrument configuration and allocated two 12 mm laparoscopic trocars for the bedside assistant. The choice between the three- or four-robotic arm configuration was based on the lead surgeon's preference, which determined the degree of involvement of the bedside assistant in the procedure, highlighting the flexibility of the Hugo RAS platform.

Before docking, arm carts were placed 45 to 60 cm away from the patient, with three arm carts positioned behind the patient's back, the fourth arm in front, and the energy tower at the foot of the bed. Docking and tilt angles were adjusted according to the side of the lesion. This configuration was used for standard RAPN for solid lesions and tumors with cystic features without differences in trocar placement and docking settings [21].

The lead surgeon, bedside assistants, and scrub nurses underwent technical training on the Hugo™ RAS System provided by Medtronic at the ORSI Academy in Aalst, Belgium. All operations were conducted by a single surgeon (R.P.), who possesses significant expertise in minimally invasive partial nephrectomy (PN) and off-clamp techniques through a standard transperitoneal approach. The surgical arrangement included monopolar curved shears, a fenestrated grasper, and a large needle driver configured for three instruments. Critical steps included making an incision along the Toldt line, mobilizing the kidney, separating it from the perirenal fat tissue, and directly accessing the renal mass. Bleeding

from the resection area was controlled using monopolar energy, and the renorrhaphy was performed with a 2/0 Monocryl single-running suture utilizing a sliding-clips technique. Hemostasis was further secured by applying hemostatic agents (TABOTAMP fibrillar™ and TachoSil®) to the renal edge when necessary to prevent postoperative bleeding and other complications. The procedure was completed by closing Gerota's fascia and placing a drain after confirming stable hemostasis [22].

2.4. Follow-Up Schedule

After the surgery, a follow-up plan was set up, which included the following:

- Laboratory tests: blood panel, electrolytes, and renal function tests at one month post-operation, with subsequent evaluations every three months.
- Abdominal CT scan: performed three months after the surgery and then every six months thereafter.

3. Results

All patients successfully underwent off-clamp minimally invasive PN without the need for conversion or additional port placement. Baseline and demographic data are displayed in Table 1. Group A showed a lower preoperative eGFR rate and a higher clinical tumor size, while group B displayed a higher number of male patients and bilateral lesions. Median preoperative hemoglobin was 13.6 (IQR, 13–14.7) and 14.8 (IQR, 12.8–15.4), for group A and group B, respectively. Median preoperative creatinine was 0.98 (IQR, 0.81–1.17) and 0.94 (IQR, 0.79–1.03) for group A and group B, respectively. Median clinical tumor size was 47.5 (IQR, 34–55) for group A and 31 (IQR, 25.5–48.5) for group B. All 6 patients in group A had a single lesion ($n = 6$, 100%) with a 50% distribution between right and left side ($n = 3$, 50%), while 13 patients ($n = 13$, 81.2%) in group B had a single lesion with the other 3 patients having two lesions ($n = 2$, 18.8%), an almost equal right–left side distribution ($n = 7$, 43.7%; $n = 8$, 50%). Only a single patient displayed bilateral lesions in group B ($n = 1$, 6.3%). Clinical T stage varied from T1a to T2a with no statistically significant difference between the two groups ($p = 0.72$). Median R.E.N.A.L. score was 7 (IQR, 5–9) and 6 (IQR, 5–7) for group A and group B, respectively. However, all these differences were not statistically significant (all $p > 0.1$).

Regarding perioperative data (Table 2), group A showed a lower operative time (IQR, 79.5 vs. 134.5 min, $p = 0.01$); while group B showed a higher trend of benign histology (62.5% vs. 33.3%). Median estimated blood loss (EBL) was 200 (IQR, 100–500) and 150 (IQR, 100–350), for group A and group B, respectively ($p = 0.68$). One minor post-operative complication, for each group, was recorded (Clavien-Dindo II, $p = 0.79$), with a case of fever in group A and a case of blood transfusion in group B, reflecting the lower need of postoperative blood transfusion in the RAPN series. Median length of stay (LOS) was 4 days (IQR, 3–5 days) for group A and 3.5 (IQR 3–6 days) for group B ($p = 0.87$). Serum creatinine at discharge in group A was 0.91 (IQR, 0.82–1.12) and 0.93 (IQR, 0.73–1.21) in group B, respectively. At discharge, eGFR was 67.9 (IQR, 63.5–69.6) in group A and 82 (IQR, 58.7–92.3) in group B. Serum creatinine and eGFR at discharge were comparable to preoperative values. Primary histology was cystic clear cell renal cell carcinoma (ccRCC) in three cases (50%) for group A and in nine (56.3%) cases for group B and cystic papillary RCC in the remaining three patients (50%) and 7 (43.7%) patients for group A and group B, respectively. Only one patient in group B displayed positive surgical margins with no positive surgical margins in group A ($p = 0.002$). The rate of trifecta achievement was 100% and 87.5% ($p = 0.01$) for group A and B, respectively.

Table 1. Baseline and demographic for RAPN and Laparoscopic PN.

Variable	RAPN (n = 6) Group A	Laparoscopic PN (n = 16) Group B	p-Value
Age (n, median, IQR)	68.5 (62–72)	67.5 (53–69.5)	0.55
Gender (n, %)			
- Male	- 3 (50%)	- 11 (68.7%)	0.62
- Female	- 3 (50%)	- 5 (31.3%)	
BMI (kg/m ² , median, IQR)	27.3 (26.4–28.2)	26.5 (23.9–29.8)	0.82
ASA score (n, %)			
- I	- 1 (16.7%)	- 0 (%)	0.18
- II	- 5 (83.3%)	- 14 (87.5%)	
- III	- 0 (0%)	- 2 (12.5%)	
- IV	- 0 (0%)	- 0 (0%)	
Charlson Comorbidity Index (median, IQR)	4 (4–5)	4.5 (3.5–5)	0.96
Diabetes (n, %)	1 (16.7%)	3 (18.7%)	0.91
Hypertension (n, %)	3 (50%)	10 (62.5%)	0.59
Preoperative Hemoglobin (g/dL, median, IQR)	13.6 (13–14.7)	14.8 (12.8–15.4)	0.30
Preoperative Creatinine (mg/dL, median, IQR)	0.98 (0.81–1.17)	0.94 (0.79–1.03)	0.48
Preoperative eGFR (mL/min/1.73 m ² , median, IQR)	69.5 (47.5–74.3)	84.3 (70–90.4)	0.12
Clinical Tumor Size (mm, median, IQR)	47.5 (34–55)	31 (25.5–48.5)	0.30
Number of Lesion (n, %)			
- 1	- 6 (100%)	- 13 (81.2%)	0.25
- 2	- 0 (0%)	- 3 (18.8%)	
cT (n, %)			
- T1a	- 2 (33.3%)	- 8 (50%)	0.72
- T1b	- 3 (50%)	- 6 (37.5%)	
- T2a	- 1 (16.7%)	- 2 (12.5%)	
Side (n, %)			
- Right	- 3 (50%)	- 7 (43.7%)	0.41
- Left	- 3 (50%)	- 8 (50%)	
- Bilateral	- 0 (0%)	- 1 (6.3%)	
R.E.N.A.L. score (median, IQR)	7 (5–9)	6 (5–7)	0.19

Table 2. Perioperative data for RAPN and Laparoscopic PN.

Variable	RAPN (n = 6) Group A	Laparoscopic PN (n = 16) Group B	p-Value
Docking Time (min, median, IQR)	5.5 (4–6)	-	-
Operative Time (min, median, IQR)	79.5 (58–91)	134.5 (90–191.5)	0.01
Estimated blood loss (mL, median, IQR)	200 (100–500)	150 (100–350)	0.68
Clavien Dindo Complications (n, %)			
- I	- 0 (0%)	- 0 (0%)	0.18
- II	- 1 (16.7%), fever	- 1 (6.2%), blood transfusion	
- III	- 0 (0%)	- 0 (0%)	
- IV	- 0 (0%)	- 0 (0%)	
Length of Stay (days, median, IQR)	4 (3–5)	3.5 (3–6)	0.87

Table 2. Cont.

Variable	RAPN (n = 6) Group A	Laparoscopic PN (n = 16) Group B	p-Value
Hemoglobin at discharge (g/dL, median, IQR)	11 (8.9–11.9)	11.25 (10.5–12.6)	0.37
Creatinine at discharge (mg/dL, median, IQR)	0.91 (0.82–1.12)	0.93 (0.73–1.21)	0.79
eGFR at discharge (mL/min/1.73 m ² , median, IQR)	67.9 (63.5–69.6)	82 (58.7–92.3)	0.88
Readmission (n, %)	0 (0%)	0 (0%)	-
Pathological Size (mm, median, IQR)	41.5 (25–55)	32.5 (26.5–45.5)	0.43
Histology_subtype (n, %)			
- Cystic Clear Cell RCC	- 3 (50%)	- 9 (56.3%)	0.41
- Cystic Papillary RCC	- 3 (50%)	- 7 (43.7%)	
Positive Margins (n, %)	0 (0%)	1 (6.2%)	0.002
pT Stage (n, %)			
- 1a	- 3 (50%)	- 10 (62.5%)	0.39
- 1b	- 1 (16.7%)	- 4 (25%)	
- 2a	- 1 (16.7%)	- 0 (0%)	
- 2b	- 0	- 0 (0%)	
- 3a	- 1 (16.7%)	- 2 (12.5%)	
Trifecta achievement rate (%)	6 (100%)	14 (87.5%)	0.01

4. Discussion

Cystic renal cell carcinomas (RCCs) are a relatively uncommon type, making up 2.5–12% of all RCC cases [23]. However, recent advances in diagnostic imaging and the implementation of the Bosniak renal cyst classification system have made it easier to distinguish between benign and malignant cystic masses. Bosniak I and II cysts are usually benign and may not need further monitoring. On the other hand, Bosniak IV cysts, which are mostly malignant (83%), display pseudo-cystic changes exclusively. Managing Bosniak IIF and III cysts poses challenges for clinicians [24]. A nephron-sparing approach still remains the recommended treatment for renal masses, whenever technically feasible, even when displaying cystic features. In comparison to solid neoplasms, PN for cystic renal masses hinders the risk of cystic wall rupture due to intraoperative kidney manipulation. This could lead to tumor spillage and the theoretical risk of increased likelihood of local recurrence, mostly in case of final adverse pathology. Even if the current literature reports contrasting evidence on the oncological implications of cyst rupture during PN, surgeons may avoid employing a minimally invasive approach to potentially fragile cystic tumors due to the necessity for advanced surgical proficiency. Nevertheless, there is contrasting evidence as many studies suggest that cyst rupture has no negative impact on oncological outcomes without any risk of local or metastatic recurrence [25,26]. In a recent series, Pradere et al. analyzed oncologic outcomes in patients undergoing PN with intraoperative cyst rupture and compared them with those of patients who did not experience rupture. The study found no cases of peritoneal carcinomatosis, local, or metastatic recurrence among patients in the subgroup where intraoperative cyst rupture occurred. Additionally, Estimated Recurrence-Free Survival (RFS) did not significantly differ between patients with and without intraoperative cyst rupture, standing at 100% versus 92.7% at 5 years ($p = 0.20$) [27].

Conversely, other studies have reported a higher risk of recurrence following cyst rupture, particularly with higher pathological types. For example, Chen et al. demonstrated a higher recurrence rate associated with cyst wall rupture. Kaplan–Meier analysis showed that 5-year RFS and 5-year Cancer-Free Survival (CFS) were worse in patients with cyst rupture compared to those without ($p = 0.006$ and 0.003 , respectively). Multivariate Cox analysis identified intraoperative cyst rupture as an independent risk factor for 5-year

RFS and 5-year CFS ($p = 0.039$ and 0.013 , respectively). However, there was no significant difference in overall survival (OS) between the two groups ($p = 0.275$). They also associated the risk of cyst rupture with higher E and N values in the R.E.N.A.L. nephrometry score, surgeon experience, and Bosniak III classification [28].

In a recent systematic review, Wang et al. found that RAPN is a safe and effective method for treating cystic renal tumors, providing perioperative, long-term functional, and oncologic outcomes equivalent to those of solid tumors [29]. However, to date few studies showed the benefits of robotic system application in the context of RAPN for cystic tumors, compared to the other approaches. Many studies reported that RAPN showed longer operative times compared to the laparoscopic and open approaches. No statistically significant difference was recorded regarding LOS, EBL, WIT, eGFR decline, peri- and postoperative complications. Comparing solid and cystic renal tumors, there are contrasting opinions on operative time without any other significant difference [30–33].

In the present study, we report the first comparison between laparoscopy and robot-assisted surgery with Hugo™ RAS System for cystic renal neoplasms, showing the high efficiency of robotic platform application in the setting of PN. The complexity of laparoscopic cystic tumor removal has consistently been shown by longer operative time, need for post-operative blood transfusion, and positive surgical margins (PSM) at final pathology. Regarding PSM, we acknowledge the small sample size and the minimal difference of only one patient. However, the RAPN group had zero PSM, and the difference compared to the LPN group was statistically significant ($p = 0.002$). Further studies with larger and more heterogeneous cohorts will help clarify this difference in PSM.

Therefore, the RAPN group exhibited a higher rate of trifecta attainment compared to the LPN ($p = 0.01$). On the other hand, hemoglobin at discharge as well as renal function was comparable and preserved in both groups (all $p > 0.36$). Satisfactory results may be expected considering the extensive experience in minimally invasive PN of the surgical staff and the enhanced dexterity provided by the robotic platform in comparison to traditional laparoscopy.

Several factors likely contributed to the favorable outcomes of our RAPN series and the absence of cystic rupture. Firstly, our unique setup, facilitated by the versatility of the Hugo™ RAS System, met specific procedural needs and provided greater comfort during high-precision surgeries. Developed by Medtronic, the Hugo™ RAS System has emerged as a significant alternative to the traditional Da Vinci system. This new platform features enhanced modularity with separate arm carts, potentially minimizing docking time and reducing the risk of accidental clashes between robotic and laparoscopic instruments. These improvements are particularly crucial in RAPN surgeries, where seamless collaboration between the lead surgeon and the bedside assistant is essential to minimize the risk of significant intraoperative bleeding or tumor rupture. The controllers, designed with “pistol-like” grips, provide superior ergonomics and precise control, especially important for delicate tasks. Additionally, the system’s “trigger” mechanism adds stability, reducing strain on the surgeon’s hand and wrist.

The success of RAPN also hinges on smooth communication between the lead surgeon and the surgical team. The Hugo™ RAS enhances this with its non-immersive console, enabling clear instructions and coordination. Combined with the ergonomic design of the instruments and the advanced functionality of the console, this setup aims to boost intraoperative efficiency, manage unexpected bleeding more effectively, and minimize the risk of incidents that could harm the patient.

Secondly, our configuration, which included two laparoscopic instruments, gave the bedside assistant a more central role. This arrangement allowed the simultaneous use of two surgical suctions with irrigation, providing clearer visualization of tumor borders during enucleation. This technique enabled precise differentiation between healthy renal parenchyma and the renal mass.

There are few studies comparing outcomes of PN for cystic tumors between robotic and laparoscopic methods. Girgis et al. found that RAPN had lower EBL than both open and laparoscopic approaches, but data on LOS, complications, outcomes, recurrence rate, and cancer-specific survival remain limited [16]. Calpin et al. reported no significant differences in ischemia time, intraoperative complications, positive surgical margins, and trifecta rate among open, laparoscopic, and robotic PN. However, RAPN and LPN had fewer postoperative complications and shorter LOS compared to open PN, and both had reduced EBL, with RAPN showing the best overall outcomes [34]. Wurnschimmel et al. noted longer operative times for RAPN compared to LPN due to the use of selective ischemia in RAPN and total ischemia in LPN [35].

In a retrospective study by Chang K.D. et al. involving 1308 patients over a median 5-year follow-up, similar oncological outcomes were observed across open, laparoscopic, and robotic PN, with comparable rates of local recurrence, distant metastasis, and cancer-related deaths. Perioperative outcomes showed RAPN had lower EBL and shorter hospital stays compared to both open PN and LPN. Additionally, RAPN had a lower incidence of CKD upstaging and a higher 5-year CKD-free survival rate compared to LPN and open PN [36].

In the present study we report no statistically significant difference between laparoscopic and robotic approaches except for the operative time which was significantly lower in RAPN series compared to the LPN one (p -value = 0.01) despite the docking time. EBL, LOS, and reduction in renal function valued through postoperative creatinine and eGFR showed no statistically significant differences between the two groups. No significant postoperative complication has been recorded in the two groups (Clavien–Dindo grade ≥ 3). The rate of trifecta achievement was 100% and 87.5% ($p = 0.01$) for group A and B, respectively.

We recognize several limitations in this study, notably its single-center design and relatively small sample size with short follow-up, which are considered primary drawbacks. Additionally, despite the favorable outcomes and efficient docking system of the Hugo™ RAS, it is essential to acknowledge that the procedures were performed by a team with extensive expertise in purely off-clamp LPN. Therefore, these results may have limited generalizability and require validation through larger-scale studies with longer follow-up periods. Nevertheless, this study marks the first report on the outcomes of PN conducted with the Hugo™ RAS, and the first study comparing conventional LPN with RAPN for PN in cystic renal masses, providing interesting insights on the application of minimally invasive approaches for high-risk rupture tumors. Moreover, regardless of the minimally invasive approach chosen, experience and proficiency in PN seemed to be the key factor to assess acceptable post-operative renal function, comparable to the pre-operative values.

5. Conclusions

In conclusion, this study underscores the significance and relevance of RAPN in the context of cystic renal masses. Through continuous evaluation and enhancement, RAPN has set the standard for nephron-sparing procedures, delivering optimal oncological and functional outcomes in renal surgery. The introduction of the Hugo™ RAS System further elevates peri-operative care, achieving satisfactory results while maintaining patient safety. RAPN's precision in tumor excision and renal function preservation makes it the preferred choice for complex renal surgeries. The unveiled RAPN's advantages over laparoscopic procedures included reduced operative time, fewer blood transfusions, and improved surgical margins, showing how prior laparoscopic partial nephrectomy (LPN) experience can facilitate the RAPN learning curve. Surgeon expertise and technological advancements are crucial for the safe application of minimally invasive techniques in urological oncology.

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