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Laparoscopic Partial Nephrectomy vs. Open Partial Nephrectomy Early Milestone: Epigrams from Sudan

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Abstract

Background: Partial nephrectomy is recognized as the gold standard treatment for localized renal cell carcinoma (RCC). While open partial nephrectomy has long been a conventional approach, the advent of laparoscopic surgical techniques has led numerous institutions worldwide to adopt laparoscopic partial nephrectomy (LPN) as the preferred method. Although comparative studies have evaluated these two surgical modalities, conclusive recommendations favoring one technique over the other remain elusive. The objective of this investigation was to assess the oncological outcomes associated with laparoscopic versus open partial nephrectomy. **Methodology:** This study encompassed a cohort of 38 patients who underwent laparoscopic partial nephrectomy (11 patients) or open partial nephrectomy (27 patients) at the Kuwaiti Specialized Hospital in Khartoum, Sudan between 2020 and 2023. A meticulous review of patient records was conducted, encompassing preoperative data, intraoperative parameters, and postoperative follow-up information. Statistical analyses were performed using SPSS software version 26. **Results:** The study comprised 38 patients, with 11 in the laparoscopic group and 27 in the open group. The mean age of participants was 57.6 years (±16). No significant differences were noted in the baseline characteristics or clinical presentations of the two cohorts. However, the laparoscopic group exhibited a longer operative time ($p = 0.005$) and ischemia time ($p = 0.03$). Additionally, no notable differences were observed in estimated blood loss ($p = 0.224$), surgical margin status ($p = 0.35$), or rates of local recurrence ($p = 0.5$). Neither group experienced port-site recurrence, and no patients presented with distant metastasis. Furthermore, there

were no significant changes in serum creatinine levels or estimated glomerular filtration rates in either group ($p = 0.4$ and $p = 0.15$, respectively). **Conclusion:** Laparoscopic partial nephrectomy demonstrates oncological outcomes that are comparable to those of open partial nephrectomy, with no significant differences in surgical margin status, local recurrence, or distant metastasis. This approach is deemed safe and exhibits advantages such as reduced invasiveness, diminished postoperative pain, and expedited recovery to normal activities, rendering it a viable treatment option even in low-income settings. Nonetheless, open partial nephrectomy remains the preferred choice in circumstances where laparoscopic techniques are not feasible or when adequate surgical expertise is lacking.

Subject Areas

Nephrology, Urology

Keywords

Partial Nephrectomy, Laparoscopy, Sudan, RCC

1. Introduction

Partial nephrectomy (PN) has become recognized as the gold-standard treatment for localized renal tumours, balancing effective cancer control with the preservation of renal function. The incidence of renal cell carcinoma (RCC) is on the rise, making it increasingly important to understand various surgical options. Traditionally, open partial nephrectomy (OPN) has set the standard due to its established efficacy in tumor excision and nephron preservation. However, the evolution of minimally invasive surgical techniques has led to the growing acceptance of laparoscopic partial nephrectomy (LPN) as a viable alternative.

Numerous studies have compared OPN and LPN, assessing a range of outcomes, including operative time, postoperative recovery, and long-term renal function. For instance, a randomized controlled trial by Taneja *et al.* (2010) demonstrated that LPN is associated with a significant reduction in intraoperative blood loss and shorter hospital stays compared to OPN, establishing it as a favorable option for patients with small tumors less than 4 cm in size [1]. In contrast, Grocott *et al.* (2012) raised concerns about the technical challenges and steeper learning curve associated with laparoscopic techniques, suggesting that these factors may contribute to increased complication rates among less experienced surgeons [2].

The introduction of robotic-assisted laparoscopic surgery has further advanced laparoscopic methodologies, allowing for increased precision and reduced postoperative morbidity. Research by Gandaglia *et al.* (2016) indicates that robotic partial nephrectomy achieves oncological outcomes comparable to OPN, while also facilitating enhanced postoperative recovery [3].

Recent studies have systematically compared OPN and LPN across a number

of parameters, including operative time, postoperative recovery, complications, and long-term renal function. A noteworthy systematic review by Rassweiler *et al.* (2016) found that laparoscopic approaches typically result in reduced intraoperative blood loss and shorter hospital stays compared to OPN, underscoring LPN's potential advantages for patients presenting with smaller tumors (<4 cm) [4]. Conversely, a study conducted by Mazzola *et al.* (2020) emphasized the technical demands and a potentially steeper learning curve present within laparoscopic techniques, which could increase complication rates among less experienced surgeons [5].

The advent of robotic-assisted laparoscopic surgery has revolutionized the laparoscopic approach, offering enhanced precision and potentially decreased rates of postoperative complications. Research by Ghanem *et al.* (2021) indicates that robotic partial nephrectomy yields comparable oncological outcomes to OPN while promoting improved postoperative recovery metrics and shorter hospital stays [6].

Numerous studies have been conducted to compare laparoscopic NSS with open NSS, particularly in developed countries where laparoscopic surgery is now considered the standard technique. However, the laparoscopic approach poses some limitations and challenges in developing countries, as these nations often have limited resources and a lack of expertise in performing such surgeries [7].

Recent studies have focused on comparing robotic partial nephrectomy to laparoscopic partial nephrectomy, while older studies compare the laparoscopic and open approaches. However, some of these older studies still raise concerns about the comparability of the laparoscopic approach to the open partial nephrectomy concerning positive surgical margins, local recurrence, and distal metastasis rates [8].

Therefore, it is essential to consider the limitations and challenges of the laparoscopic approach in developing countries and continue studying the efficacy and safety of different surgical techniques for NSS. This will enable healthcare providers to make informed decisions about the best surgical approach to adopt, depending on the available resources and expertise.

2. Patients and Methods

This retrospective study evaluates partial nephrectomy as a nephron-sparing surgical approach for patients with renal tumors. The primary objective of this investigation is to compare the oncological outcomes associated with laparoscopic partial nephrectomy and open partial nephrectomy.

2.1. Study Area

The study was conducted at Kuwaiti Specialized Hospital in Khartoum, which serves as one of the principal urological surgical centres in the region. It is among the limited facilities in Sudan that perform laparoscopic urological surgeries.

2.2. Study Population

Patients who underwent either open or laparoscopic partial nephrectomy during the specified period were included in the study.

Inclusion Criteria: All patients who underwent partial nephrectomy at Kuwaiti Specialized Hospital during the designated timeframe were included, with the exception of those meeting the exclusion criteria.

Exclusion Criteria: Patients who missed follow-up appointments were excluded from the analysis. In fact, no one missed the follow-up period, which was assigned to be for 12 months.

2.3. Sample Size

The sample comprised all patients who underwent surgical procedures during the study period and satisfied the inclusion criteria.

2.4. Data Collection Tools and Methods

Patient records from 2020 to 2023 were comprehensively reviewed. Data collected encompassed preoperative parameters, surgical details, postoperative investigations, and follow-up information. Additionally, histopathology results, including tumor type and margin status, were evaluated.

Surgical Procedures

Laparoscopic surgeries were exclusively performed by one surgeon, while all open surgeries were conducted by a separate, single surgeon to minimize variability in surgical expertise and skill. Open surgery was conducted when there were problems with equipment junk or missed parts or on the patient's requests or in cases of comorbidities or anaesthetist advice.

Laparoscopic Partial Nephrectomy: The procedure was executed via a retroperitoneal approach utilizing three ports, with the camera port facilitating tumor retrieval.

Both surgeon's skills and experience were comparable.

Open Partial Nephrectomy: This procedure involved a flank incision to access the renal mass.

In both surgical approaches, the renal hilum was identified, and the renal artery was clamped using a vascular clamp. Resection margins were outlined using diathermy before arterial clamping to reduce ischemia time, thereby mitigating potential negative effects on renal function and glomerular filtration rate (GFR). The renal tissue was subsequently sutured, and hemostasis was carefully achieved before closing the surgical site. The excised tumor tissue was sent to the laboratory for histopathological examination.

SSI and wound healing problems were assessed as a part of our surgery mandatory audit, and there were not any significant differences to be added. Our mortality was zero.

2.5. Data Analysis

Data analysis was performed using SPSS version 26.0 for Windows. The Kolmogorov-

Smirnov test was applied to assess the normality of the variable distributions, with a p-value threshold of >0.05 indicating normality. Parametric data were summarized using median, mean, and standard deviation (SD), while qualitative data were expressed as counts and percentages. Comparisons between laparoscopic and open surgical techniques were conducted accordingly.

2.6. Ethical Considerations

Ethical approval was obtained from the Sudan Medical Specialization Board (SMSB). Ethical permission was obtained from the hospital where the patients had been operated on. All data collected was used concerning patient confidentiality.

2.7. Disclosure

We have nothing to disclose.

3. Results

The total number of patients enrolled in this study was 38. Of these, 11 underwent laparoscopic partial nephrectomy (LPN), compared to 27 who underwent open partial nephrectomy (OPN) in Kuwaiti specialized hospital (2020-2023).

The basic characteristics of both laparoscopic and open surgery groups are shown in Table 1.

Table 1. Differences between laparoscopic and open surgery groups regarding basic characteristics (n = 38).

		Total (n = 38)	OPN (n = 27)	LPN (n = 11)	p-value
Age (year), mean		57.6 ± 13.0	57.7 ± 13.5	57.5 ± 12.4	
Gender	Male	19 (50%)	16 (59.3%)	8 (72.7%)	
	Female	19 (50%)	11 (40.7%)	3 (27.3%)	
Baseline Hemoglobin (mean)		13.1 ± 1.3	13.0 ± 1.3	13.2 ± 1.4	0.7121
Baseline creatinine (mean)		1.1 ± 0.5	1.1± 0.4	1.1± 0.9	0.264
Baseline eGFR (mean)		76.1 ± 23.0	73.1 ± 22.2	83.5 ± 24.2	0.231

OPN = Open partial nephrectomy. **LPN** = Laparoscopic partial nephrectomy. **eGFR** = Estimated glomerular filtration rate.

Table 2. Tumours symptoms and characteristics (n = 38).

		Total (n = 38)	OPN (n = 27)	LPN (n = 11)	p-value
Tumor size, cm (median)		4.5 (2 - 13)	5.6 (2 - 13)	2.9 (2 - 4)	0.00
Side	Right	14 (36.8%)	9 (33.3%)	5 (45.5%)	0.561
	Left	22 (57.9%)	16 (59.3%)	6 (54.5%)	
	Solitary kidney	2 (5.3%)	2 (7.4%)	0	
Complain	Accidentally	21 (55.3%)	16 (59.3%)	5 (45.5%)	0.438
	Pain	15 (39.5%)	10 (37.0%)	5 (45.5%)	0.630
	Haematuria	2 (5.3%)	2 (7.4%)	0	0.354

OPN = Open partial nephrectomy. **LPN** = Laparoscopic partial nephrectomy.

The median operative time for the laparoscopic group was 120 minutes and 90 minutes for the open group (p = 0.005) (see Figure 1).

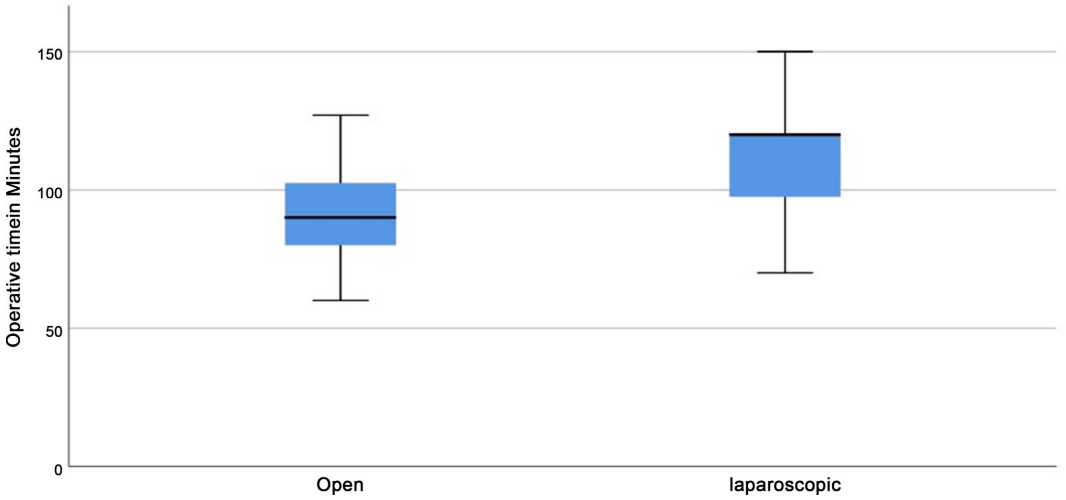

Figure 1. Boxplot of operation time among studied groups.

The median ischemia time was 22 minutes for the LPN and 18 minutes for the OPN (p = 0.03) (see Figure 2).

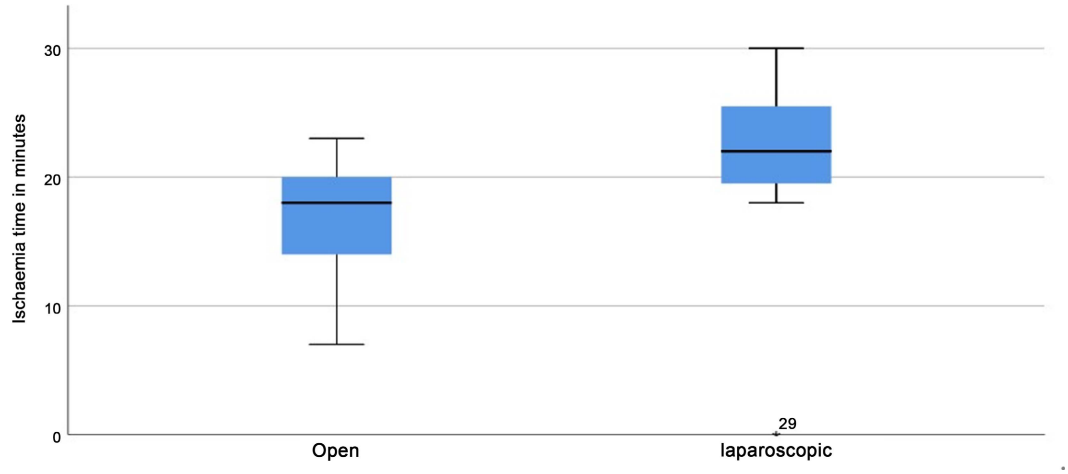

Figure 2. Boxplot of ischemia time among studied groups.

The median estimated blood loss was 50 ml for the laparoscopic group and 100 ml for the open group (p = 0.224) (see Figure 3).

The final pathology report showed that 2 OPN patients (7.4%) had benign results, while the remaining patients (25, 92.6%) were diagnosed with RCC. Notably, all patients in the LPN group were found to have Renal Cell Carcinoma in their pathology reports.

In the surgical margins, it was found that there was a free surgical margin in 92.6% of patients who underwent OPN, and in 100% of patients who underwent LPN (p = 0.35). The local recurrence of the disease was observed in only one

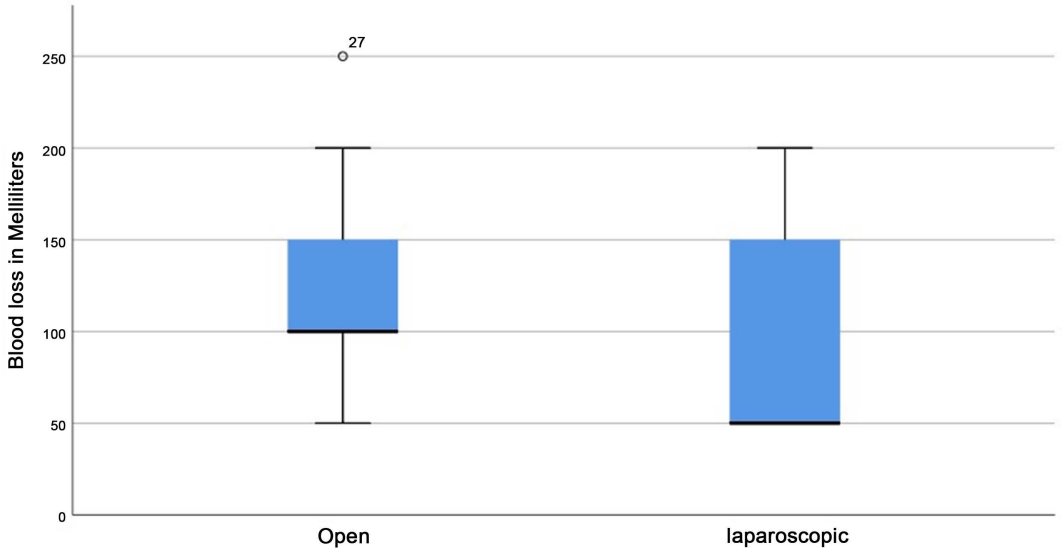

Figure 3. Boxplot of estimated blood loss among studied groups.

patient in the OPN group (3.7%), and one patient in the LPN group (9.1%) with a p-value of 0.5. Figure 3 shows the rate of local recurrence between LPN and OPN. It is noteworthy that there was no recurrence at the port site for the laparoscopy group. No patient had metastasis in either group.

Regarding the serum creatinine and eGFR after 12 months compared to the baseline readings, in the Laparoscopic group, the mean serum creatinine was 1.1 ± 0.8, the mean eGFR was 84.2 ± 25.4 (p = 0.65, 0.81, respectively), while in the OPN group, the mean for serum creatinine was 1.1 ± 0.43 and the mean eGFR was 72.1 ± 22.6, the p-values were 0.66 and 0.75 respectively. The difference in the change in serum creatinine and eGFR between the 2 groups was calculated and the p-values were 0.4 and 0.15 respectively (see Table 3).

Table 3. Differences between laparoscopic and open surgery groups regarding post-operative data (n = 38).

		Total (n = 38)	OPN (n = 27)	LPN (n = 11)	p-value
Post-operative eGFR (after 12 months)		75.6 ± 23.7	72.1 ± 22.6 (p = 0.75)	84.2 ± 25.4 (p = 0.81)	0.15
Post-operative creatinine (after 12 months)		1.1 ± 0.6	1.1 ± 0.4 (p = 0.66)	1.1 ± 0.8 (p = 0.65)	0.40
Surgical margin	Free	36 (94.7%)	25 (92.6%)	11 (100%)	0.35
	Involved	2 (5.3%)	2 (7.4%)	0	
Recurrence	Yes	2 (5.3%)	1 (3.7%)	1 (9.1%)	0.50
	No	36 (94.7%)	26 (96.3%)	10 (90.9%)	

OPN = Open partial nephrectomy. **LPN** = Laparoscopic partial nephrectomy. **eGFR** = Estimated glomerular filtration rate.

4. Discussion

Partial nephrectomy (PN) has emerged as the gold standard for the treatment of localized renal tumors, effectively balancing cancer control with the preservation

of renal function. As the incidence of renal cell carcinoma (RCC) continues to rise, it becomes increasingly critical to evaluate the various surgical options available for treatment. Historically, open partial nephrectomy (OPN) has been regarded as the benchmark due to its proven efficacy in tumor excision and nephron preservation. However, advancements in minimally invasive surgical techniques have fostered the growing acceptance of laparoscopic partial nephrectomy (LPN) as a viable alternative.

In Table 1 of this study, the mean age of the patients was 57.6 years, with a standard deviation of 13.0. Both groups exhibited similar baseline characteristics. In terms of gender distribution, the majority of patients in both groups were male; specifically, 16 patients (59.3%) in the OPN group and 8 patients (72.7%) in the LPN group were male, which aligns with international parameters. There were no statistically significant differences between the two surgical techniques concerning baseline haemoglobin levels, baseline serum creatinine levels, and estimated glomerular filtration rate (eGFR), with p-values of 0.71, 0.26, and 0.23, respectively.

Both patient groups also demonstrated similar clinical conditions. In Table 2, the median tumor size was 5.6 cm in the OPN group and 2.9 cm in the LPN group, with the LPN group having a significantly smaller tumor size ($p = 0.00$). In the laparoscopic group, nephron-sparing surgery (NSS) was performed according to guidelines for small T1a tumors. Conversely, in the open group, NSS was performed whenever possible, as shown in Table 2, regardless of tumor size. Interestingly, tumor size did not influence disease recurrence, as only one patient in the open group experienced a recurrence. This patient had translocation renal cell carcinoma (RCC), a rare and aggressive form of RCC, despite having a small tumor. A study by Paherenk *et al.* (2008) found that NSS is a safe procedure for tumors larger than 4 cm, reporting 5-year local recurrence-free survival rates of 98.5% for small tumors and 98.3% for larger tumors, with 10-year rates of 93.9% and 98.3%, respectively ($p = 0.282$) [9].

The tumors were located on the left side in 59.3% of the OPN patients and in 54.5% of the LPN patients. Among the 27 patients in the OPN group, 16 patients (59.3%) had their tumors discovered incidentally, 10 patients (37.0%) presented with loin pain, and only 2 patients (7.4%) experienced hematuria. In the LPN group, 5 patients (45.5%) had their tumors discovered incidentally, 5 patients (45.5%) reported loin pain, and non-experienced hematuria. There were no statistically significant differences between the two surgical techniques concerning the side of the tumor ($p = 0.56$) or the patients' presenting complaints ($p = 0.43$, $p = 0.63$, $p = 0.35$).

All patients in the LPN group had RCC confirmed in their final pathological reports, while 92.6% of the OPN patients were diagnosed with RCC. Pathological results indicated benign tumors in 2 patients (7.4%) in the OPN group, with no benign cases reported in the LPN group.

The operative data for both patient groups were similar. However, in Figure 1, the LPN group had a significantly longer median operation time of 120 minutes

compared to 90 minutes for the open group (p = 0.004). This finding is consistent with the literature.

The laparoscopic cohort exhibited a median ischemia time of 22 minutes, **Figure 2** and **Figure 3** contrasting with the open group's 18 minutes, revealing a notably longer warm ischemia duration for the laparoscopic partial nephrectomy (LPN) (p = 0.03). This finding aligns with a systematic review and meta-analysis by Sui *et al.* [10], as well as retrospective studies conducted by Nicaise *et al.* [11] and Kartal *et al.* [12]. Additionally, a prospective multicenter observational study by Bravi *et al.* [13] corroborated these results. Conversely, a systematic review published in 2023 by Calpin *et al.* [14], along with two retrospective studies by Soisrithong *et al.* [15] and Mehra *et al.* [16], reported no significant discrepancies in ischemia time between LPN and open partial nephrectomy (OPN). It is important to note that ischemia time may be influenced by technical factors; for instance, some surgeons release the arterial clamp prior to suturing the renal tissues to reduce ischemia duration, while others prioritize hemostasis by meticulously suturing the renal tissues—sometimes employing hemostatic agents—before releasing the clamp. This variability warrants further investigation to validate the comparisons drawn between the two surgical modalities. It is worth noting that literature has shown that laparoscopic partial nephrectomy can yield similar results to open surgery in terms of oncological outcomes, while also reducing the patient's hospital stay and recovery time [17].

Despite these differences, there were no statistically significant variations in estimated blood loss (EBL) between the two groups (p = 0.22). This observation is reinforced by two systematic reviews and network meta-analyses by Sui *et al.* [10] and Calpin *et al.* [14], as well as a retrospective study by Soisrithong *et al.* [15]. In contrast, systematic reviews of retrospective studies by Nicaise *et al.* [11] and Mehra *et al.* [16] found that LPN was associated with lower EBL compared to OPN. On the other hand, Kartal *et al.* [12] found that LPN resulted in a significantly higher EBL. These discrepancies are likely attributable to the varying levels of surgical experience among practitioners; nonetheless, most studies reported no substantial differences in EBL, suggesting that the two approaches are largely comparable in this regard.

Regarding surgical margins, our study identified a free surgical margin in 92.6% of OPN patients and 100% of LPN patients, with no statistically significant difference observed between the two groups. This outcome is consistent with the findings from systematic reviews and network meta-analyses by Calpin *et al.* [14] in 2023 and Sui *et al.* [10], both of which concluded that there were no significant differences in free surgical margins between OPN and LPN. Notably, this holds true even for complex tumors, as demonstrated by the systematic review conducted by Li *et al.* [18], which reported no statistical differences between open and minimally invasive partial nephrectomy across nine included studies.

In the year 2023, the work of Kılıç *et al.* [19] corroborated findings from earlier investigations by Mehra *et al.* in 2019 [16] and by Soisrithong *et al.* [15] in 2021.

The retrospective study led by Soisrithong *et al.* [15] notably reported the absence of any positive surgical margins (PSMs) in both the open and laparoscopic cohorts. Collectively, these studies lend robust support to our own findings regarding margin involvement in the two surgical groups under examination [14] [19]. Conversely, these results stand in stark contrast to a comprehensive systematic review and meta-analysis conducted by You *et al.* in 2020 [20], which indicated a higher occurrence of PSM in laparoscopic partial nephrectomy (PN); nevertheless, the subgroup analysis yielded no statistically significant differences. Similarly, the retrospective analysis by Kartal *et al.* [12] revealed elevated PSM rates in laparoscopic interventions, in a prospective study. Moreover, another prospective investigation by Islam *et al.* in 2021 [21] pointed to a greater prevalence of PSM in the laparoscopic cohort, attributing this phenomenon to the diminished tactile feedback inherent to laparoscopic techniques. They posited that enhancing surgical proficiency and experience could mitigate this issue.

With respect to disease recurrence, our study observed only one recurrence each in the open partial nephrectomy (OPN) and laparoscopic partial nephrectomy (LPN) groups, with no statistically significant association discovered between recurrence rates and the surgical methodologies employed ($p = 0.50$). Consistent with our findings, two systematic reviews and meta-analyses by Li *et al.* [18] and You *et al.* [20], along with a retrospective study by Nicaise *et al.* [11] found no discernible differences in local recurrence between LPN and OPN. It is worth noting, however, that the sole case of recurrence in the open group involved translocation renal cell carcinoma (RCC), a variant characterized by an aggressive clinical course, rendering the recurrence an anticipated outcome. Additionally, our study found no instances of port site recurrence within the laparoscopic cohort, and there was no evidence of metastasis present in either group.

When evaluating renal function, particularly serum creatinine levels and estimated glomerular filtration rate (eGFR) in **Table 3**, at the 12-month mark compared to baseline measurements, our analysis revealed no statistically significant differences within the laparoscopic group ($p = 0.65$ for serum creatinine and $p = 0.81$ for eGFR) or the open group ($p = 0.66$ for serum creatinine and $p = 0.75$ for eGFR). Furthermore, there was no notable distinction between the two groups in this regard ($p = 0.4$ for serum creatinine and $p = 0.15$ for eGFR). Thus, there was no decline in serum creatinine or eGFR observed in either cohort one-year post-surgery. These findings align with those of a prospective randomized clinical study conducted by Calpin *et al.* [14] in 2023, which assessed eGFR at 12 hours and 6 months post-operation, as well as with the work of Islam *et al.* [21] in 2021, who found similar results regarding serum creatinine changes. Additionally, Kartal *et al.* [12] reported no differences in eGFR on the first postoperative day, at the six-month follow-up, or during the final visit. This consistency was further supported by a prospective study conducted by Ghavimi *et al.* [22], which similarly found that the decline in renal function post-surgery was comparable between the open and laparoscopic patient groups. A systematic review and meta-analysis by You

et al. [20] in 2020 further echoed these conclusions, demonstrating no significant differences in renal function between the surgical approaches.

5. Conclusions

Laparoscopic partial nephrectomy (LPN) presents oncological outcomes that closely mirror open partial nephrectomy (OPN), exhibiting no significant differences in surgical margin status, local recurrence rates, or the incidence of distant metastasis. Although LPN is associated with prolonged operative and ischemic durations, it does not increase estimated blood loss compared to its open counterpart. Our findings affirm that LPN is a safe and equally effective procedure, offering distinct advantages such as minimal invasiveness, reduced postoperative pain, and a swifter return to normal activities. It is particularly noteworthy that in resource-limited settings like Sudan, the laparoscopic approach can be a viable alternative to open partial nephrectomy, provided that an experienced surgeon is available. Nevertheless, open partial nephrectomy remains the preferred choice in cases where laparoscopy is not feasible, or in the absence of a qualified laparoscopic surgeon.

Laparoscopic surgery in the low currency countries is yet needed and costly in the procurement, repairs, and refurbishment of the primary instillation of the services as yet. In the long run, it weighs an added value in buying time, less morbidity, early work return and other.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Taneja, S.S., Gupta, S. and Wong, A. (2010) Open versus Laparoscopic Partial Nephrectomy: A Randomized Controlled Trial. *Journal of Urology*, **183**, 220-225.

[2] Grocott, M.H., Boney, O. and Wrigley, S. (2012) The Learning Curve for Laparoscopic Surgery: A Systematic Review. *Annals of Surgery*, **256**, 782-794.

[3] Gandaglia, G., Paffoni, A., Maffei, M., *et al.* (2016) Robotic Partial Nephrectomy: A Systematic Review. *Urologic Oncology: Seminars and Original Investigations*. **34**, 291-295.

[4] Rassweiler, J., Popp, C., Teber, D., *et al.* (2018) Laparoscopic and Open Partial Nephrectomy: A Trend Analysis of the Outcomes. *European Urology*, **74**, 751-759.

[5] Mazzola, R., Marchioni, M., Klatte, T., *et al.* (2020) The Learning Curve in Laparoscopic Partial Nephrectomy: A Systematic Review. *The Journal of Urology*, **203**, 238-245.

[6] Ghanem, A., Saad, F., El-Assmy, A., *et al.* (2021) Robotic-Assisted versus Open Partial Nephrectomy: A Matched Cohort Study. *World Journal of Urology*, **39**, 4277-4283.

[7] Singh, A. and Urry, R.J. (2020) Laparoscopic versus Open Nephrectomy in Resource-Constrained Developing World Hospitals: A Retrospective Analysis. *African Journal of Urology*, **26**, Article No. 85. https://doi.org/10.1186/s12301-020-00096-9

[8] Yu, F., Xu, Q. and Liu, X. (2021) Impact of Laparoscopic Partial Nephrectomy and Open Partial Nephrectomy on Outcomes of Clear Cell Renal Cell Carcinoma. *Frontiers in Surgery*, **8**, Article 681835. https://doi.org/10.3389/fsurg.2021.681835

[9] Pahernik, S., Roos, F., Röhrig, B., Wiesner, C. and Thüroff, J.W. (2008) Elective Nephron Sparing Surgery for Renal Cell Carcinoma Larger than 4 cm. *Journal of Urology*,

179, 71-74. https://doi.org/10.1016/j.juro.2007.08.165

[10] Sui, Y., Zhang, Z., Sun, H., Zhao, K., Wang, Z., Zhang, Y., *et al.* (2020) Comparison of Laparoscopic and Open Partial Nephrectomy in the Treatment of T1 Renal Tumor: A Systematic Review and Meta-Analysis. https://doi.org/10.21203/rs.3.rs-48507/v1

[11] Nicaise, E., Feldman, A.S., Gusev, A., Yu, A., Nimmagadda, N., Wszolek, M.F., *et al.* A Contemporary Comparison of Laparoscopic versus Open Partial Nephrectomy for Renal Cell Carcinoma. *BMC Urology*, **24**, Article No. 58. https://doi.org/10.1186/s12894-024-01423-w

[12] Kartal, I., Karakoyunlu, N., Çakici, Ç., Karabacak, O., Sağnak, L. and Ersoy, H. (2020) Oncological and Functional Outcomes of Open versus Laparoscopic Partial Nephrectomy in T1b Tumors: A Single-Center Analysis. *International Brazilian Journal of Urology*: *Official Journal of the Brazilian Society of Urology*, **46**, 341-350. https://doi.org/10.1590/s1677-5538.ibju.2018.0865

[13] Bravi, C.A., Larcher, A., Capitanio, U., Mari, A., Antonelli, A., Artibani, W., *et al.* (2021) Perioperative Outcomes of Open, Laparoscopic, and Robotic Partial Nephrectomy: A Prospective Multicenter Observational Study (The Record 2 Project). *European Urology Focus*, **7**, 390-396. https://doi.org/10.1016/j.euf.2019.10.013

[14] Calpin, G.G., Ryan, F.R., McHugh, F.T. and McGuire, B.B. (2023) Comparing the Outcomes of Open, Laparoscopic and Robot-Assisted Partial Nephrectomy: A Network Meta-Analysis. *BJU International*, **132**, 353-364. https://doi.org/10.1111/bju.16093

[15] Soisrithong, C., Sirisreetreerux, P., Sangkum, P., Kijvikai, K., Viseshsindh, W., Kongchareonsombat, W., *et al.* (2021) Comparative Outcomes and Predictive Assessment of Trifecta in Open, Laparoscopic, and Robotic-Assisted Partial Nephrectomy Cases with Renal Cell Carcinoma: A 10-Year Experience at Ramathibodi Hospital. *Research and Reports in Urology*, **13**, 425-435. https://doi.org/10.2147/rru.s316824

[16] Mehra, K., Manikandan, R., Dorairajan, L.N., Sreerag, S., Jain, A. and Bokka, S.H. (2019) Trifecta Outcomes in Open, Laparoscopy or Robotic Partial Nephrectomy: Does the Surgical Approach Matter? *Journal of Kidney Cancer and VHL*, **6**, 8-12. https://doi.org/10.15586/jkcvhl.2019.115

[17] Chiancone, F., Fabiano, M., Meccariello, C., Fedelini, M., Persico, F. and Fedelini, P. (2021) Laparoscopic versus Open Partial Nephrectomy for the Management of Highly Complex Renal Tumors with PADUA Score ≥10: A Single Center Analysis. *Urologia Journal*, **88**, 343-347. https://doi.org/10.1177/03915603211001677

[18] Li, K., Chen, S., Wang, C. and Yang, L. (2023) Comparison between Minimally Invasive Partial Nephrectomy and Open Partial Nephrectomy for Complex Renal Tumors: A Systematic Review and Meta-Analysis. *International Journal of Surgery*, **109**, 1769-1782. https://doi.org/10.1097/js9.0000000000000397

[19] Kılıç, M., Çulpan, M., Yıldırım, A. and Çaşkurlu, T. (2021) Comparison of Early Experience Laparoscopic versus Open Partial Nephrectomy in Terms of Clinical, Oncological and Renal Functional Outcomes. *Yeni Üroloji Dergisi*, **16**, 116-123. https://doi.org/10.33719/yud.2021;16-2-792827

[20] You, C., Du, Y., Wang, H., Peng, L., Wei, T., Zhang, X., *et al.* (2020) Laparoscopic versus Open Partial Nephrectomy: A Systemic Review and Meta-Analysis of Surgical, Oncological, and Functional Outcomes. *Frontiers in Oncology*, **10**, Article 583979. https://doi.org/10.3389/fonc.2020.583979

[21] Islam, M.W., Naser, M.F., Hossain, M.A., Hossan, M.M., Saiduzzaman, B. and Haider, M. (2021) Nephron-Sparing Laparoscopic versus Open Surgery for T1 Renal Mass: Seven Years' Experience and Outcomes. *Journal of Current and Advance Medical Research*, **8**, 70-74. https://doi.org/10.3329/jcamr.v8i1.52747

[22] Ghavimi, S., Saarela, O., Pouliot, F., Rendon, R.A., Finelli, A., Kapoor, A., *et al.* (2020) Achieving the "Trifecta" with Open versus Minimally Invasive Partial Nephrectomy. *World Journal of Urology*, **39**, 1569-1575. https://doi.org/10.1007/s00345-020-03349-y