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Original Research Article

Factors Influencing Laparoscopic Radical Nephrectomy Over Open Nephrectomy for Large Renal Tumours (>10 cm): A 16-Year Retrospective Study from a High-Volume Tertiary Centre

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Abstract:

Background: Renal cell carcinoma (RCC) is a common kidney malignancy, and nephrectomy remains the standard treatment for large tumors (>10 cm). Open radical nephrectomy (ORN) is traditionally preferred, but laparoscopic radical nephrectomy (LRN) offers potential minimally invasive benefits.

Aim: To evaluate perioperative outcomes, tumor characteristics, and the feasibility of LRN versus ORN in managing large renal tumors.

Methodology: A retrospective observational study of 51 patients with RCC >10 cm at a high-volume tertiary center (2009–2024) was conducted. Thirty patients underwent LRN and 23 underwent ORN. Demographics, tumor characteristics, surgical variables, and postoperative outcomes were analyzed.

Results: Tumors in the LRN group were smaller (11.32 ± 1.69 cm vs. 13.5 ± 2.34 cm, p=0.001). LRN had shorter operative times (167 ± 44 min vs. 235 ± 57 min, p<0.001), lower blood loss (202 ± 186 ml vs. 605 ± 336 ml, p<0.001), and reduced hospital stay (5.1 ± 2.2 days vs. 7.2 ± 1.7 days, p=0.001). Histopathology was comparable, predominantly clear cell carcinoma, with low metastatic burden. ORN was used more for larger, complex tumors requiring additional procedures.

Conclusion: LRN is a safe and effective minimally invasive alternative to ORN for selected patients with large renal tumors, providing superior perioperative outcomes without compromising oncological efficacy.

Keywords: Renal Cell Carcinoma, Open Nephrectomy, Laparoscopic Nephrectomy, Minimally Invasive Surgery, Large Renal Tumors.

Introduction

Renal cell carcinoma (RCC) is one of the most frequent cancers of the kidney and is characterized by a continuous rise in its global incidence. Localized disease can be treated mostly with surgical excision, and the gold standard of treatment of large renal tumors is nephectomy [1]. In the past, the operations that have been used as options of treating tumors larger than 10 cm have been the open radical nephectomy (ORN) because of its perceived technical, oncological, and perioperative difficulties.

In the last twenty years, the laparoscopic methods have completely transformed Urological surgery. Laparoscopic radical nephectomy (LRN) is a newly developed procedure to replace ORN with the potential advantages of less postoperative pain, shortenings of hospitalization, expedited healing, and cosmetic appearance [2]. Although these benefits have been recognized, LRN application on large kidney tumors has been done with reservations mostly because of macromorphic renal tumors, closeness to major vessels, and the risk of intraoperative complications.

Several studies looked at the LRN about the management of small to medium sized renal tumors and the studies have shown similar outcomes oncologically with respect to ORN. Nevertheless, there is scanty evidence to use it in tumors larger than 10 cm that is heterogeneous [3]. Barriers have been cited to include technical factors, such as the inability to mobilize large kidneys, provide sufficient exposure, and manipulate hilar vessels. As a result, ORN still takes control of giant renal masses management in most of the centers.

Surgical mastery and diverse laparoscopic tools have progressively increased the LRN indications. Heavy volume tertiary centers have also obtained promising outcomes, which stipulates that it is possible that the size of the tumor can be disregarded as an excluding factor to a minimally invasive approach [4]. The experience of surgeons, choice of patients, the localization of tumors, and preoperative imaging are very important factors that determine the viability and safety of LRN in large renal tumors.

The debate on LRN and ORN revolves around patient outcomes, such as perioperative morbidity, blood loss, length of hospital stays, and oncological efficacy. Although LRN has the theoretical advantages of minimal invasive surgery, there are issues of the duration of operation, the complications during the operation, and the extent of clearance of the tumor. The factors are vital in informing clinical decision-making and setting evidence-based protocols [5].

Although there are accumulating results of research on minimally invasive nephrectomy, limited studies have compared LRN and ORN under tumors more than 10 cm long-term conditions. High-volume centers are especially useful in long-term retrospective studies, which allow assessing changes in surgical practice, complication rates, and oncological outcomes, which can lead to additional changes in the integration of laparoscopic methods into practice [6].

The research will address the gap in knowledge by examining a 16-year experience of radical nephectomy to cure large tumors of the renal parenchyma in a high-volume tertiary centre. When exploring the effect of factors affecting the decision to use LRN or ORN, perioperative outcomes and oncological efficacy, we aim to understand the relevance of minimally invasive surgery in the treatment of tricky renal tumors [7]. This evidence can be used to create sophisticated instructions and help the surgeon to develop an individual approach to treatment of patients and tumors.

Overall, even though ORN has been the gold standard in the treatment of large renal tumors, LRN is a prospective treatment that is minimally invasive. Patient selection, surgical proficiency, and development of technological innovations have paved the safe use of LRN in the right case over time. The given study will be a full retrospective analysis of the factors that can affect the approach to surgery and will inform the modern practice and make the treatment of patients with large renal tumors more efficient.

Methodology

Study Design: This was a retrospective observational study conducted over a 16-year period to evaluate the factors influencing the choice of laparoscopic radical nephrectomy (LRN) over open radical nephrectomy (ORN) for large renal tumours (>10 cm).

Study Area: The study was carried out at the Department of Urology, Kovai Medical Center and Hospital (KMCH), Coimbatore, a high-volume tertiary care centre.

Study Duration: The study included cases from January 2009 to December 2024.

Study Participants: A total of 51 patients with renal cell carcinoma (RCC) larger than 10 cm were included in the study. Of these, 30 patients underwent LRN, and 21 patients underwent ORN.

Inclusion Criteria

- Patients aged above 18 years
- Radiologically and pathologically confirmed RCC
- Tumour size greater than 10 cm
- Patients who underwent either LRN or ORN

Exclusion Criteria

- Non-RCC renal tumours
- Secondary Malignancies
- Incomplete medical or operative data

Sample Size: The final sample size comprised of 51 patients.

Procedure: Patient data were retrospectively retrieved from hospital records, including demographic details, comorbidities, tumour characteristics, histopathological findings, staging, operative variables, intraoperative blood loss, hospital stay, additional procedures performed, and postoperative outcomes, including recurrence. Surgical approach—either LRN or ORN—was chosen based on tumour characteristics, surgeon expertise, and patient factors. Standardized operative techniques were employed for both LRN and ORN, and all surgeries were performed by experienced urologists in a high-volume tertiary centre.

Statistical Analysis: Continuous variables were expressed as mean ± standard deviation or median as appropriate. Comparisons between groups were performed using the student's t-test or the Mann–Whitney U test for continuous variables and the Chi-square test for categorical variables. A p-value of <0.05 was considered statistically significant. Data will be entered into Microsoft Excel and analyzed using SPSS version 27.

Result

Table 1 shows the demographics and clinical features of patients who have the laparoscopic (n=30) and the open nephectomy (n=21). There was no significant difference in the age (57.43 ± 13.77 vs. 55.19 ± 14.1 years, p=0.899) and body mass index (24.54 ± 3.55 vs. 24.24 ± 2.43 kg/m 2, p=0.724). The

males (73.3 vs. 57.1) were higher in the laparoscopic group whereas females (26.7 vs. 42.9) were lower. The symptoms were similar across groups with the most prevalent ones being loin pain (33.3% vs. 38.1) and hematuria (30% vs. 23.8) but incidental findings were more common in the laparoscopic group compared to the open surgery group (26.7% vs. 14.3%). The history of the previous abdominal surgery was noticed in 26.7 percent of laparoscopic and 42.9 percent of open nephrectomy patients. In general, no statistically significant differences were found in the measured baseline characteristics of the groups.

Table 1: Patient Baseline Demographics and Clinical Characteristics

Variable	Laparoscopic Nephrectomy (n=30)	Open Nephrectomy (n=21)	P Value
Age (years)	57.43 ± 13.77	55.19 ± 14.1	0.899*
Sex	Male: 22 (73.3%)	Male: 12 (57.1%)	
	Female: 8 (26.7%)	Female: 9 (42.9%)	–
BMI (kg/m²)	24.54 ± 3.55	24.24 ± 2.43	0.724*
Presentation	Loin pain: 10 (33.3%)	Loin pain: 8 (38.1%)	
	Hematuria: 9 (30%)	Hematuria: 5 (23.8%)	
	Incidental: 8 (26.7%)	Incidental: 3 (14.3%)	
	Weight loss: 1 (3.3%)	Weight loss: 3 (14.3%)	
	Loin pain + Hematuria: 2 (6.7%)	Loin pain + Hematuria: 1 (4.8%)	–
	Mass palpable: 0	Mass palpable: 1 (4.8%)	
Past Abdominal Surgical History	8 (26.7%)	9 (42.9%)	–

Table 2 provides a summary of the gross tumor features of patients that underwent laparoscopic and open nephrectomy. The laparoscopy group had much smaller tumors with a mean of 11.32 +1.69 +1.71 cm in opposition to the open surgery group that had a mean of 13.5 +2.34 +2.45 cm (p= 0.001). The laparoscopic group had a laterality of the tumor close to 50 percent left and 50 percent right whereas the open group had a higher number of left side tumors (71.4% left vs. 28.6% right). The tumor polarity differed between both groups with mid and lower pole tumors prevalent in the laparoscopic group (33.3) and all poles involvement being more prevalent in the open (28.57) group. There were small differences between the groups in other polar distributions. In both groups, all the tumors were unifocal. In general, laparoscopic tumors were smaller in size and more lateralized whereas open nephectomy cases were larger and with complex tumors that affected more than one pole.

Table 2: Tumor Characteristics – Gross

Variable	Laparoscopic Nephrectomy (n=30)	Open Nephrectomy (n=21)	P Value
Tumor size (cm)	11.32 ± 1.69	13.5 ± 2.34	0.001*
Laterality	Left: 15 (50%)	Left: 15 (71.4%)	–
	Right: 15 (50%)	Right: 6 (28.6%)	
Polarity	Mid & lower pole: 10 (33.33%)	Mid & lower pole: 4 (19.05%)	
	Upper & mid pole: 7 (23.33%)	Upper & mid pole: 6 (28.57%)	
	Lower pole: 9 (30%)	Lower pole: 3 (14.29%)	
	Others: 3 (10%)	All poles: 6 (28.57%)	
	Upper pole: 1 (3.33%)	Others: 1 (4.76%)	–
		Upper pole: 1 (4.76%)	
Focality	Unifocal: 30 (100%)	Unifocal: 21 (100%)	–

Table 3 is a summary of tumor characteristics among patients that underwent laparoscopic and open nephectomy. The most common histopathological type observed in both groups was clear cell carcinoma (70 versus 57.1 percent) followed by papillary RCC and chromophobe RCC, but the proportion of chromophobe tumors was greater in the open group. Tumors of high grade were also common, especially grade 4 (40% laparoscopic vs. 28.6% open) and grade 3 (26.7% vs. 38.1%). The majority of the tumors were at an advanced pathological stage (pT3a was the most frequent in both groups 66.7 vs. 52.4), and pT4 tumors were more prevalent in the open nephectomy cases (23.8 vs. 13.3). The nodal involvement was typically low, PN0 was the most common, PN1 was higher in the open group (23.8% vs. 10%). The distant metastases were infrequent but a little more common in patients undergoing open nephectomy (M1: 14.3% vs. 3.3%). In general, there were more distinct cell histology in both groups and a high tumor stage as well as low metastatic burden with small variations in grade, subtype, and nodal or distant involvement.

Table 3: Tumor Characteristics – Histology		
Variable	**Laparoscopic Nephrectomy (n=30)**	**Open Nephrectomy (n=21)**
Histopathological type		
Clear cell carcinoma	21 (70%)	12 (57.1%)
Papillary RCC	3 (10%)	4 (19.1%)
Chromophobe RCC	1 (3.33%)	3 (14.3%)
Others	5 (16.67%)	2 (9.52%)
Grade		
Grade 4	12 (40%)	6 (28.6%)
Grade 3	8 (26.67%)	8 (38.1%)
Grade 2	9 (30%)	6 (28.6%)
Grade 1	1 (3.33%)	1 (4.8%)
Pathological T stage (pT)		
pT3a	20 (66.67%)	11 (52.4%)
pT4	4 (13.33%)	5 (23.8%)
pT2b	4 (13.33%)	2 (9.5%)
pT2a	1 (3.33%)	1 (4.8%)
pT1	1 (3.33%)	1 (4.8%)
pT3b	–	1 (4.8%)
PN stage		
PN0	25 (83.33%)	16 (76.2%)
PN1	3 (10%)	5 (23.8%)
PN2	2 (6.67%)	–
M stage		
M0	29 (96.66%)	18 (85.7%)
M1	1 (3.33%)	3 (14.3%)

Table 4 compared the results of laparoscopic and open nephrectomy in surgery. Laparoscopic nephectomy recorded reduced operative time (167 44.03 min vs. 234.76 56.98 min, P = 0.001), less estimated blood loss (202 186.2 ml vs. 604.76 336.49 ml, P = 0.001) and reduced hospital stay (5.12 2.16 days vs. 7.192.72 days P = 0.00 In the laparoscopic group, adrenalectomy was more common (26.67 vs. 14.29) as compared to lymphadenectomy, IVC thrombectomy and cytoreductive nephrectomy which were more in the open group. Other procedures rates and renal bed recurrence were also similar between the groups. In general, laparoscopic nephrectomy was found to be more efficient and associated with faster recovery of the patient and more complicated surgeries were addressed by open surgery.

Table 4: Surgical Outcomes			
Variable	**Laparoscopic Nephrectomy (n=30)**	**Open Nephrectomy (n=21)**	**P Value**
Duration of procedure (min)	167 ± 44.03	234.76 ± 56.98	<0.001*
Estimated blood loss (ml)	202 ± 186.2	604.76 ± 336.49	<0.001**
Hospital stays (days)	5.1 ± 2.16	7.19 ± 1.72	0.001**
Adrenalectomy	8 (26.67%)	3 (14.29%)	–
Lymphadenectomy	5 (16.67%)	8 (38.1%)	–
IVC Thrombectomy	1 (3.33%)	3 (12.5%)	–
Cytoreductive nephrectomy	2 (6.67%)	7 (33.33%)	–
Others	4 (13.33%)	3 (14.29%)	–
Renal bed recurrence	1 (3.33%)	1 (4%)	–

Discussion

The patient demography and patient clinical characteristics of the cases of laparoscopic vs. open nephrectomy were similar in most cases. The age/BMI distributions of both groups were comparable, the differences in the sex ratios were not significant. The symptoms also lacked a distinct presentation with most similar cases being loin pain and hematuria despite the incidental tumors being a bit higher in the laparoscopic group. The history of previous abdominal surgery was slightly greater with the open nephew but generally these pre-requisite features indicate that the patients that were selected to have either of the two surgeries were pretty much well-balanced. The oncologic results of limited renal cell carcinoma (pT1-pT2) with a follow-up of about 4

years were reported by Lou et al., (2010) [8] and found that LRN and ORN had the same outcome, and the tumor stage is an independent prognostic factor of CSS of localized RCC.

Gross tumor characteristics analysis showed significant variations in tumor size and complexity. Laparoscopic group had very small tumors than the open surgery group. The distribution of tumor laterality was also balanced in laparoscopic group, but left-sided tumors dominated open group. There was a greater percentage of mid-pole and lower-pole tumours in laparoscopic cases than in open nephrectomy, which suggests that open surgery is more likely to select more complicated tumours. The unifocal tumors were exclusive to both groups, which justifies the comparability of focality of tumors. In patients with tumor volume greater than 10 cm and pathological stages of pT2/pT3c and pT4, Capitanio et al, (2014) [9] observed that the number of lymph nodes removed by LND was related to disease-free survival (DFS) and CSS.

Histopathological findings showed in both groups that the most common subtype of renal cell carcinoma was clear cell carcinoma, which was followed by papillary and chromophobe RCC in lesser amounts. The tumors were very high grade, and most of them were grade 4 in the laparoscopic and grade 3 in the open group. Pathological staging revealed that the most common was pT3a, with slightly more open group having pT4 tumors. There were an overall low nodal involvement and distant metastases, but the open category had a greater percentage of PN1 and M1. All in all, there was a general similarity in tumor biology, with open surgery having slightly higher patients with advanced disease. According to Gu et al., (2017) [10] it was recommended that robot-assisted radical nephrectomy (RARN) was more effective in the control of EBL than ORN in the management of renal carcinoma in combination with IVC thrombosis (250 vs. 1000 ml, $p < 0.001$).

Laparoscopic nephectomy was apparent to be more efficient and perioperative recovery. Compared to open surgery, laparoscopy surgeries had much shorter operating periods, less blood losses, and shortened hospitalization. Using more invasive techniques like lymphadenectomy, IVC thrombectomy as well as cytoreductive nephrectomy were more commonly done through open surgery, the choice of such cases being of more complex cases. Adrenalectomy rates were higher in the laparoscopic group and renal bed recurrence was not prevalent and comparable in the two cohorts. Dillenburg et al., (2006) [11] suggested that retroperitoneal laparoscopic radical nephectomy (RLRN) was more advantageous than ORN in intraoperative complications (52 vs. 100 $p < 0.001$) and comparable short-term oncologic results.

In conclusion laparoscopic nephrectomy offered definite perioperative benefits and reduced operative time, blood loss and recovery time especially on small, less complicated tumors. Open nephrectomy was applied more often to larger and more complicated tumors and cases that required further intervention, and a somewhat advanced tumor stage and metastatic load. The results of the research demonstrate the necessity to consider the specifics of the surgical technique depending on the characteristics of the tumor and emphasize the effectiveness and safety of minimally invasive methods.

Conclusion

This 16-year retrospective analysis shows that while laparoscopic radical nephrectomy (LRN) offers clear perioperative advantages over open radical nephrectomy (ORN), including reduced blood loss, shorter operative time, and faster recovery, its success depends not only on surgical expertise but also on favourable patient and tumour characteristics. LRN is more feasible in patients who provide adequate laparoscopic working space—such as tall individuals or females with a more compliant, less muscular abdomen, including postpartum patients. Tumour-related factors also play a critical role; LRN is most successful when the tumour is confined to the kidney, has involvement limited to the renal vein, offers adequate pedicle length, and shows minimal nodal or fibrofatty tissue around the pedicle. When these favourable anatomical and oncological conditions are present, combined with sufficient surgical skill and proper case selection, LRN serves as a safe, effective, and minimally invasive alternative to ORN without compromising oncological outcomes.

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