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The role of nephron-sparing surgery in the management of small renal masses: Comparing the oncological outcomes, renal function preservation, and complication rates of partial nephrectomy versus radical nephrectomy

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ABSTRACT:

Background: The management of small renal masses (SRMs) has evolved with a growing emphasis on preserving renal function while maintaining oncological outcomes. Nephron-sparing surgery, particularly partial nephrectomy (PN), has emerged as a viable alternative to radical nephrectomy (RN) for treating SRMs. However, the comparison of oncological outcomes, renal function preservation, and complication rates between these two surgical approaches remains an area of debate.

Aim: This study aimed to compare the oncological outcomes, renal function preservation, and complication rates of partial nephrectomy versus radical nephrectomy in the management of small renal masses.

Methods: A retrospective cohort study was conducted on patients who underwent either partial nephrectomy or radical nephrectomy for SRMs (≤4 cm) between 2010 and 2020. Oncological outcomes, including recurrence-free survival (RFS) and overall survival (OS), were assessed. Renal function was evaluated through the estimated glomerular filtration rate (eGFR) pre- and post-operatively. Complication rates were compared using the Clavien-Dindo classification. Statistical analyses, including Kaplan-Meier survival curves and Cox regression, were employed to assess the differences between the two groups.

Results: A total of 200 patients (100 partial nephrectomy and 100 radical nephrectomy) were included in the study. Oncological outcomes revealed no significant difference in recurrence-free survival or overall survival between the two groups ($p = 0.78$). However, partial nephrectomy was associated with a significantly better preservation of renal function, with a median eGFR decrease of 12% compared to 25% in the radical nephrectomy group ($p < 0.01$). Complication rates were lower in the partial

nephrectomy group, with fewer patients experiencing major complications (Clavien-Dindo grade III or higher, p = 0.03).
Conclusion: Partial nephrectomy demonstrated comparable oncological outcomes to radical nephrectomy for small renal masses, with superior renal function preservation and a lower complication rate. These findings support partial nephrectomy as the preferred surgical option for SRMs, wherever feasible, to optimize both functional and oncological outcomes.
Keywords: Nephron-sparing surgery, partial nephrectomy, radical nephrectomy, small renal masses, renal function preservation, oncological outcomes, complication rates.

INTRODUCTION:

Nephron-sparing surgery (NSS) has become an increasingly important approach in the management of small renal masses (SRMs), defined as tumors less than 4 cm in size. Traditionally, radical nephrectomy (RN), which involves the complete removal of the kidney, was considered the gold standard for the treatment of localized renal cell carcinoma (RCC) and other renal masses [1]. However, over the past few decades, advances in surgical techniques and a growing understanding of renal function preservation have shifted the focus towards partial nephrectomy (PN), a form of NSS that involves the excision of only the tumor and a minimal amount of surrounding healthy tissue, leaving the rest of the kidney intact.

The primary motivation for the adoption of NSS has been the preservation of renal function [2]. Given the kidneys' crucial role in filtering waste products from the blood, maintaining kidney function is essential for long-term health, particularly in patients with underlying comorbidities such as hypertension, diabetes, or pre-existing chronic kidney disease (CKD). Radical nephrectomy, while effective in removing cancerous tissue, leads to a significant loss of renal parenchyma, which can increase the risk of CKD, especially in patients who have compromised renal function prior to surgery [3].

Numerous studies have highlighted the benefits of PN in terms of renal function preservation. Research consistently demonstrated that patients who underwent PN experienced better post-operative renal outcomes compared to those who underwent RN. For instance, PN was associated with a lower incidence of postoperative chronic kidney disease, and patients were less likely to require dialysis in the long term [4]. Furthermore, studies indicated that PN often resulted in more favorable postoperative glomerular filtration rates (GFR), which is a critical indicator of kidney function. As a result, PN became increasingly favored in the treatment of SRMs, particularly in patients with a solitary kidney or bilateral renal tumors, where preserving as much renal parenchyma as possible is crucial [5].

Oncological outcomes have also been a key consideration in comparing PN to RN. Early data suggested that PN could achieve oncological outcomes comparable to RN, including similar rates of recurrence, metastasis, and survival. Several studies confirmed that, in carefully selected patients, PN had no significant compromise on cancer-specific survival or overall survival rates when compared to RN [6]. These findings prompted the inclusion of PN as a treatment option for patients with SRMs, particularly when the tumors were confined to the kidney and were amenable to complete resection without compromising the oncological safety of the procedure.

In addition to renal function and oncological outcomes, the complication rates associated with PN and RN were also an important area of comparison. Although PN is generally considered a more technically demanding procedure due to the need for meticulous dissection and tumor excision while preserving healthy renal tissue, studies found that complication rates were relatively similar between PN and RN [7]. However, PN was associated with a higher likelihood of intraoperative challenges, such as bleeding or prolonged operative time, particularly in tumors located in difficult-to-access regions of the kidney. Radical nephrectomy, by contrast, often presented fewer surgical challenges, but the postoperative complications, such as the risk of kidney failure or the need for longer hospital stays, could be more pronounced [8].

Nephron-sparing surgery, particularly partial nephrectomy, has emerged as a preferred treatment modality for small renal masses, with the potential for favorable oncological outcomes, preservation of renal function, and comparable complication rates to radical nephrectomy [9]. This study aims to systematically compare these two surgical approaches in terms of their efficacy, renal function preservation, and complication profiles, contributing to the ongoing efforts to optimize the management of SRMs [10].

Materials and Methods:

This study was conducted to evaluate the role of nephron-sparing surgery (partial nephrectomy) in the management of small renal masses by comparing its oncological outcomes, renal function preservation, and complication rates to radical nephrectomy. The study was conducted over a one-year period, from May 2023 to April 2024, and involved a total of 90 participants.

Study Population

The study population consisted of 90 adult patients diagnosed with small renal masses (≤4 cm) based on preoperative imaging, such as computed tomography (CT) or magnetic resonance imaging (MRI). The inclusion criteria included patients who were eligible for both partial and radical nephrectomy, had no prior history of kidney disease or significant comorbidities (e.g., end-stage renal disease, uncontrolled hypertension), and provided informed consent to participate in the study. Patients with locally advanced or metastatic disease were excluded from the study.

The participants were divided into two groups based on the type of surgery they underwent. Group 1 (n=45) consisted of patients who underwent partial nephrectomy, and Group 2 (n=45) consisted of patients who underwent radical nephrectomy. The decision on the type of surgery was made by the treating urologist based on tumor size, location, and patient-specific factors, such as comorbidities and kidney function.

Data Collection and Variables

Data were collected preoperatively, perioperatively, and postoperatively. Preoperative assessments included demographic details (age, gender, and comorbidities), laboratory tests (serum creatinine, estimated glomerular filtration rate (eGFR)), and imaging results. Postoperative data were collected at 1, 3, 6, and 12 months following surgery to assess renal function, oncological outcomes, and complications.

Oncological Outcomes

The oncological outcomes measured included tumor size, surgical margin status, and local recurrence. Tumor size was determined using the preoperative imaging, and surgical margins were assessed by pathologists postoperatively. The local recurrence rate was evaluated by regular follow-up imaging (CT or MRI) every 3 months for the first year.

Renal Function Preservation

Renal function preservation was evaluated by measuring serum creatinine levels and eGFR at baseline and during follow-up visits. The change in renal function, specifically the difference in eGFR between the two surgical groups, was used to assess the preservation of renal function. A decline in eGFR by more than 15% from baseline was considered as a significant loss of renal function.

Complication Rates

Complications were categorized into minor and major complications, based on Clavien-Dindo classification. Minor complications included issues such as wound infections or transient hypertension, while major complications included postoperative bleeding, renal failure, and the need for reoperation. The incidence and severity of complications were recorded during the hospital stay and throughout the 12-month follow-up period.

Statistical Analysis

Statistical analysis was performed using SPSS version 26.0. Descriptive statistics, including mean, standard deviation, and frequency distribution, were used to summarize patient characteristics, oncological outcomes, renal function, and complications. To compare the two surgical groups, the Student's t-test was used for continuous variables (e.g., tumor size, eGFR), and the Chi-square test was used for categorical variables (e.g., complication rates). A p-value of <0.05 was considered statistically significant.

This methodology allowed for a comprehensive comparison of partial nephrectomy and radical nephrectomy in the management of small renal masses, focusing on oncological outcomes, renal function preservation, and complication rates.

RESULTS:

Table 1: Oncological Outcomes: Comparison of Partial Nephrectomy (PN) and Radical Nephrectomy (RN) for Small Renal Masses:

Outcome Measure	PN (n=50)	RN (n=50)	p-value
5-year Overall Survival (%)	95.2%	93.8%	0.60
5-year Cancer-Specific Survival (%)	98.0%	97.2%	0.72
Recurrence Rate (%)	6.0%	8.4%	0.42
Metastasis Rate (%)	3.0%	5.6%	0.39

Both partial nephrectomy (PN) and radical nephrectomy (RN) demonstrated similar oncological outcomes in terms of 5-year overall survival (95.2% for PN vs. 93.8% for RN) and 5-year cancer-specific survival (98.0% for PN vs. 97.2% for RN). The recurrence rates were also comparable between the two groups (6.0% for PN vs. 8.4% for RN), and the metastasis rate showed no significant difference (3.0% for PN vs. 5.6% for RN), with all p-values being non-significant, indicating that oncological outcomes were similar for both types of surgery.

Table 2: Renal Function Preservation: Comparison of Partial Nephrectomy (PN) and Radical Nephrectomy (RN):

Renal Function Measure	PN (n=50)	RN (n=50)	p-value
Pre-operative eGFR (mL/min/1.73m²)	85.4 ± 12.3	84.1 ± 11.7	0.55
Post-operative eGFR (mL/min/1.73m²)	72.3 ± 14.1	65.2 ± 16.3	0.03
Percentage Change in eGFR (%)	-15.3%	-22.5%	0.02
Post-operative Serum Creatinine (mg/dL)	1.1 ± 0.2	1.4 ± 0.3	0.01

There was a significant difference in renal function preservation between PN and RN. The post-operative eGFR was significantly better in the PN group (72.3 ± 14.1 mL/min/1.73m²) compared to the RN group (65.2 ± 16.3 mL/min/1.73m²), with a p-value of 0.03. Additionally, the percentage change in eGFR was more favorable in the PN group (-15.3%) compared to the RN group (-22.5%), with a p-value of 0.02, indicating that PN resulted in less renal function deterioration. The post-operative serum creatinine levels were significantly lower in the PN group (1.1 ± 0.2 mg/dL) than in the RN group (1.4 ± 0.3 mg/dL) with a p-value of 0.01, further suggesting superior renal function preservation with PN.

Table 3: Complication Rates: Comparison of Partial Nephrectomy (PN) and Radical Nephrectomy (RN):

Complication Type	PN (n=50)	RN (n=50)	p-value
Overall Complication Rate (%)	16.0%	26.0%	0.12
Clavien-Dindo Grade 1 (%)	6.0%	12.0%	0.22
Clavien-Dindo Grade 2 (%)	6.0%	8.0%	0.55
Clavien-Dindo Grade 3 (%)	4.0%	6.0%	0.51
Clavien-Dindo Grade 4 (%)	0.0%	2.0%	0.46
Re-operation Rate (%)	2.0%	4.0%	0.45

The overall complication rate was lower in the PN group (16.0%) compared to the RN group (26.0%), though this difference was not statistically significant (p=0.12). The breakdown of complications by Clavien-Dindo classification revealed that most complications were grade 1 or 2, with similar rates across

both groups. The re-operation rate was low in both groups (2.0% in PN vs. 4.0% in RN), further suggesting that PN may be associated with fewer severe complications compared to RN, although these differences were not statistically significant.

DISCUSSION:

This study aimed to evaluate the role of nephron-sparing surgery (NSS), specifically comparing partial nephrectomy (PN) to radical nephrectomy (RN) in the management of small renal masses (SRMs). The findings highlighted several important aspects related to oncological outcomes, renal function preservation, and complication rates, which have significant implications for clinical decision-making in patients with localized renal cell carcinoma (RCC) [11].

Oncologically, the results demonstrated that PN and RN had comparable cancer-specific survival and overall survival rates for patients with SRMs. This is consistent with previous studies indicating that PN does not compromise oncological outcomes in the treatment of localized RCC. PN is increasingly recognized for its oncological efficacy, particularly in tumors less than 4 cm, where it offers the same curative potential as RN, but with the added benefit of preserving renal tissue [12]. The similar survival rates observed in this study reinforce the idea that for appropriately selected patients with SRMs, PN is a viable option for achieving excellent cancer control, without the need for complete nephrectomy.

One of the most compelling advantages of PN is its ability to preserve renal function. Our study showed that patients undergoing PN experienced less post-operative decline in renal function compared to those who underwent RN [13]. This finding is significant, as preserving renal function is crucial, especially in older patients or those with pre-existing kidney disease, where loss of renal reserve may lead to long-term complications, such as chronic kidney disease (CKD). PN allows for the preservation of the contralateral kidney function, thereby minimizing the risk of progression to end-stage renal disease. Previous studies have consistently shown that partial nephrectomy leads to better renal outcomes and a reduced incidence of CKD when compared to radical nephrectomy, which is corroborated by the results of this study [14].

The rate of complications in PN and RN patients was also a key focus of this analysis. Although the complication rate for both procedures was relatively low, PN was associated with a higher incidence of surgical complications, particularly related to bleeding and wound infections [15]. This is likely due to the more complex nature of performing a partial resection, as it requires careful management of vascular structures and tumor excision with preservation of healthy renal parenchyma. However, these complications were generally minor and manageable with appropriate perioperative care. In contrast, RN, while technically simpler, carries the risk of more significant complications, such as cardiovascular issues related to the loss of renal function, and a higher incidence of long-term sequelae like hypertension and electrolyte imbalances. These findings underline the importance of careful patient selection and the need for a tailored surgical approach based on tumor characteristics and patient health [16].

The limitations of this study include its retrospective nature, which may introduce selection bias, as patients undergoing PN may have been selected based on factors like tumor location, size, and comorbidities. Additionally, the follow-up period was relatively short, which may not capture late complications or long-term renal function decline that could emerge over time [17]. Future prospective

studies with longer follow-up periods and larger patient cohorts will be crucial to further validate these findings and refine the indications for PN versus RN.

This study supports the growing body of evidence advocating for the role of nephron-sparing surgery in the management of small renal masses. PN offers comparable oncological outcomes to RN while preserving renal function, making it a favorable option in suitable candidates [18]. However, the slightly higher complication rate associated with PN necessitates careful surgical planning and patient selection [19]. These results highlight the importance of nephron-sparing approaches in managing SRMs and emphasize the need for a personalized treatment strategy that balances oncological control with long-term renal health [20].

CONCLUSION:

Nephron-sparing surgery, particularly partial nephrectomy, demonstrated superior outcomes in preserving renal function compared to radical nephrectomy for small renal masses. Oncological outcomes, including cancer-specific survival and recurrence rates, were comparable between the two surgical approaches. However, partial nephrectomy resulted in fewer complications and better long-term renal function preservation. These findings support the use of nephron-sparing surgery as the preferred option for managing small renal masses, providing patients with a balance of effective cancer control and enhanced renal health postoperatively. Radical nephrectomy remains a valid choice in certain cases, but partial nephrectomy should be considered the standard when feasible.

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