

ORIGINAL ARTICLE

Comparative Outcomes between Off-Clamp and On-Clamp Nephron-Sparing Surgery – A Retrospective Analysis

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Masud Rana¹, N I Bhuiyan², Abu Sayed³, M A Arafat⁴, Hasibul Islam⁵, Muntasir Chowdhury⁶

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Correspondence to
Masud Rana

ORCID
<https://orcid.org/0009-0002-0144-3607>

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ABSTRACT

Objective: To compare perioperative and functional outcomes between off-clamp and on-clamp techniques during nephron-sparing surgery (NSS). **Methods & Materials:** A retrospective study of 70 patients who underwent NSS for renal tumors between January 2020 and July 2025. Patients were divided into two groups: Off-Clamp NSS (Group A, n=34) and On-Clamp NSS (Group B, n=36). Data on operative time, estimated blood loss (EBL), warm ischemia time (WIT), complications, and renal functional outcomes (eGFR changes) were analyzed. **Results:** Group A showed significantly higher EBL ($p=0.02$) but better postoperative renal function preservation (mean eGFR drop: 5.6% vs 11.4%, $p<0.001$). Group B had shorter operative times and less intraoperative bleeding. No significant difference was observed in complication rates or oncologic margin positivity. **Conclusion:** Off-clamp NSS offers superior renal functional preservation compared to on-clamp NSS at the expense of higher blood loss. Patient selection remains crucial, and off-clamp NSS may be particularly beneficial in younger patients with baseline impaired renal function.

Keywords: Partial nephrectomy, Off-clamp technique, On-clamp technique, Nephron-sparing surgery, Warm ischemia, Estimated blood loss, Renal function preservation, eGFR decline, Positive surgical margin, Perioperative outcomes

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1. Assistant Professor, Department of Urology, Bangladesh Medical College, Dhaka, Bangladesh
2. Associate Professor, Department of Urology, Bangladesh Medical College, Dhaka, Bangladesh
3. Assistant Professor, Department of Urology, Kidney foundation hospital and research institute, Dhaka, Bangladesh
4. Assistant Professor, Department of Urology, Bangladesh Medical College, Dhaka, Bangladesh
5. Associate Professor (CC), Department of Urology, Enam Medical College, Savar, Dhaka, Bangladesh
6. Consultant, Department of Urology, Bangladesh Medical College Hospital, Dhaka, Bangladesh

INTRODUCTION

Renal cell carcinoma (RCC) is one of the most common urological malignancies, and the incidence of incidentally detected small renal masses has increased in recent decades due to the widespread use of cross-sectional imaging.^[1] Nephron-sparing surgery (NSS), or partial nephrectomy, is now widely accepted as the standard of care for localized renal tumors, particularly those classified as stage T1, because it achieves excellent oncological control while preserving renal function.^[2,3] One of the major intraoperative considerations during NSS is whether to clamp the renal hilum to provide a bloodless surgical field (on-clamp technique) or to perform tumor excision without hilar clamping (off-clamp technique). The on-clamp approach facilitates precise tumor resection and renorrhaphy by minimizing blood loss but carries the risk of ischemia-reperfusion injury, which may negatively impact

postoperative renal function.^[4] Conversely, the off-clamp approach avoids ischemic injury but can be associated with higher intraoperative blood loss and increased technical difficulty.^[5] The optimal approach continues to be debated, as surgeons must balance intraoperative safety with long-term renal function preservation. This study was conducted to compare perioperative, functional, and oncological outcomes between off-clamp and on-clamp NSS with particular attention to renal function outcomes.

MATERIALS & METHODS

A retrospective review was conducted on 70 patients who underwent NSS between January 2020 and July 2025 at Bangladesh Medical College and Hospital. Patients were divided into two groups: Off-Clamp NSS (n=34) and On-Clamp NSS (n=36). Inclusion criteria: Age 18–75 years, solitary unilateral renal mass ≤ 7 cm (T1a/T1b), and preoperative

eGFR ≥ 60 mL/min/1.73m². Exclusion criteria: solitary kidney, bilateral tumors, prior renal surgery. Parameters assessed: operative time, estimated blood loss, warm ischemia time, complications (Clavien-Dindo), positive surgical margin (PSM), and pre/postoperative eGFR (1 and 6 months). Continuous variables were analyzed using Student's t-test, categorical variables with Chi-square, and $p < 0.05$ was considered significant.

RESULTS

Total 70 patients included in our study. Group A showed significantly higher EBL ($p = 0.02$) but better postoperative renal function preservation (mean eGFR drop: 5.6% vs 11.4%, $p < 0.001$). Group B had shorter operative times and less intraoperative bleeding. No significant difference was observed in complication rates or oncologic margin positivity.

Table – I: Comparison of Perioperative and Functional Outcomes Between Off-Clamp and On-Clamp Partial Nephrectomy

Parameter	Off-Clamp (n=34)	On-Clamp (n=36)	p-value
Operative time (min)	110 $\pm$ 24	95 $\pm$ 20	0.01
Estimated blood loss (mL)	398 $\pm$ 102	272 $\pm$ 85	0.02
Warm ischemia time (min)	N/A	19.4 $\pm$ 3.3	N/A
Intraoperative complications (%)	5.8%	5.6%	0.94
Post-op eGFR decline (%)	5.6%	11.4%	<0.001
Positive surgical margins (%)	2.9%	5.5%	0.71

DISCUSSION

The present study highlights the trade-offs between off-clamp and on-clamp NSS. Consistent with prior reports, our results demonstrate that the off-clamp technique provides superior renal function preservation, as evidenced by the significantly lower decline in postoperative eGFR compared to the on-clamp group.^[4-6] This benefit is particularly relevant for patients with pre-existing renal impairment, solitary kidneys, or those at high risk for chronic kidney disease progression. However, this functional advantage came at the expense of higher intraoperative blood loss and slightly prolonged operative times. Importantly, these intraoperative challenges did not translate into increased complication rates, suggesting that the off-clamp approach is safe when performed by experienced surgeons. The lack of difference in positive surgical margin rates between groups reinforces the oncologic safety of both techniques, in agreement with previously published series.^[5,6] The decision to employ an on-clamp or off-clamp strategy should therefore be individualized, taking into account tumor complexity, baseline renal function, and surgeon expertise. Our findings suggest that off-clamp NSS may be especially advantageous in younger patients or those with impaired renal reserve, while on-clamp NSS remains a practical option for technically challenging tumors where surgical precision and hemostasis are paramount. Limitations of this study include its retrospective design, relatively small sample size, and potential selection bias, as surgical approach was determined by surgeon preference. Prospective randomized trials are required to provide more definitive evidence regarding the optimal approach to NSS.

CONCLUSION

Off-clamp nephron-sparing surgery offers superior postoperative renal function preservation compared to the traditional on-clamp approach, albeit with increased blood loss and longer operative times. Careful patient selection and surgeon expertise are essential to optimize outcomes.

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