Analysis of Risk Factors for Perioperative Complications Following Open and Laparoscopic Nephrectomy in Patients with Non-Functioning Kidneys: A Retrospective Cohort Study

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Abstract

Non-functioning kidneys are a common indication for nephrectomy, especially in resource-limited settings. Minimally invasive nephrectomy is preferred over open surgery because it reduces perioperative morbidity; however, how patient-related factors such as anemia, body mass index, and immunonutritional markers affect complication risk remains poorly defined. This retrospective cohort study examined perioperative outcomes and predictors of complications in 44 patients who underwent nephrectomy for non-functioning kidneys at a tertiary center in Indonesia between January 2022 and October 2025. Laparoscopic nephrectomy was used in 68% of cases, with markedly lower intraoperative blood loss (median 150 vs. 500 cc; approximately 73% reduction), a shorter median hospital length of stay (3 vs. 4.5 days), and earlier drain removal (3 vs. 4 days) compared with open surgery. These results align with prior studies highlighting laparoscopy's benefits in reducing morbidity and expediting recovery. Overall, 32% of patients experienced intra- or postoperative complications. Open nephrectomy significantly increased the risk of complications (OR 4.0, p=0.049). Preoperative anemia (OR 8.7, p=0.006) and underweight status (OR 11.7, p=0.001) emerged as primary risk factors, emphasizing the importance of transfusion needs and the adverse nutritional impacts across major surgical interventions. In contrast, a high neutrophil-to-lymphocyte ratio, a high platelet-to-lymphocyte ratio, and a low prognostic nutritional index despite being commonly observed were not significantly associated with perioperative complications in this retrospective cohort. For benign nephrectomy addressing non-functioning kidneys, the most effective approach to curbing perioperative complications is to prioritize laparoscopic surgery coupled with systematic management of anemia and undernutrition

Keywords: Nephrectomy, Perioperative Complication, Inflammatory Marker, Body Mass Index

INTRODUCTION

A non-functioning kidney can result from many causes, including obstructive or recurrent pyelonephritis, xanthogranulomatous pyelonephritis (XGP), and calculous disease. Nephrectomy remains the definitive treatment for symptomatic non-functioning kidneys. This is especially true when urinary tract infections occur frequently, the patient experiences chronic pain, or there are other reasons to suspect malignant transformation. It is reported 32% to 84% of all nephrectomy procedures globally are for benign non-functioning kidneys, with developed countries reporting a prevalence of about 12-33%, while in developing countries, especially in resource-limited settings, due to late diagnosis and inadequate access to modern diagnostic and therapeutic modalities, the prevalence is above 50% (Jha et al., 2024; Thiam et al., 2019).

Nephrectomy can be performed via laparoscopy or an open approach. The choice between open and laparoscopic nephrectomy has shifted over the past two decades. Lower operative trauma rate, shorter hospital stays, and less postoperative pain have favored the laparoscopic approach. However, both methods carry major postoperative complications, including hematoma formation, renal fistula formation, sepsis, adjacent organ injury, and vascular injury (Jha et al., 2024; Alsmadi et al., 2025).

Postoperative complications and operative difficulty in nephrectomy have been linked to multiple risk factors. Efforts to eliminate these risk factors have focused on modifiable preoperative factors, such as nutritional status and hematologic profile. Recent studies have linked these risk factors to operative difficulty, postoperative complications, and the duration of abdominal drain placement (Artykov et al., 2023; Jha et al., 2024; Kierstan et al., 2020).
Nutritional status is assessed using BMI, which shows a complex pattern in postoperative outcomes. Recent evidence indicates that both underweight patients (BMI < 18.5 kg/m²) and those with morbid obesity (BMI > 40 kg/m²) face substantially higher risks of postoperative complications than patients with normal-to-overweight BMI. Underweight patients have fewer nutritional reserves and are particularly vulnerable to malnutrition when systemic inflammation is present (Kott et al., 2020). Hematologic profiles, such as anemia, are independent, modifiable risk factors with significant implications for postoperative complications. A growing number of high-quality prospective studies have established that optimizing hemoglobin concentration through iron supplementation and/or erythropoietin can reduce postoperative morbidity, as measured by length of hospital stay or other objective indices, across various major surgical procedures (Ali et al., 2022; Li et al., 2022).

The neutrophil-to-lymphocyte ratio (NLR) and the platelet-to-lymphocyte ratio (PLR) are two other hematologic profiles that can be used to predict complications after surgery. They are easy to obtain and cheap markers of systemic inflammation. Elevated preoperative NLR has been associated with a higher risk of postoperative complications and surgical site infections across various surgical specialties, including anastomotic leaks, as well as increased mortality. Likewise, an increased preoperative PLR correlates with inflammatory responses and hemostatic complications. It has been shown to be a prognostic indicator with acceptable validity for surgical outcomes. The Prognostic Nutritional Index (PNI) is a biomarker that shows both nutritional and immune status. It has been shown to be a good predictor of complications after surgery for a number of different types of surgery. The lower the PNI score, the higher the complication and mortality rates. However, there are no specific studies demonstrating its efficacy as a predictor of complications from nephrectomy, particularly for

nonfunctioning kidneys, highlighting an important gap that needs to be addressed in this area of research (Fuss et al., 2022; Garbens et al., 2017; Meng et al., 2022; Li et al., 2022; Qian et al., 2023; Templeton et al., 2014).

To date, there are limited studies that have taken into account a number of preoperative inflammation and nutritional factors, as well as clinical factors, when trying to predict complications in postoperative patients, especially those related to nephrectomy of non-functional kidneys. This knowledge gap necessitates a comprehensive analysis comparing open and laparoscopic approaches to optimize patient selection and surgical planning.

The aim of this study is to identify independent risk factors for postoperative complications after open and laparoscopic nephrectomy in patients with non-functioning kidneys, with particular attention to preoperative inflammatory markers (NLR and PLR) and nutritional status (PNI) as potential predictive variables.

METHODS

This is a retrospective cohort study conducted at the Department of Urology, Faculty of Medicine, Universitas Gadjah Mada, Sardjito Hospital, Yogyakarta, Indonesia. Patient data were collected from medical records and operative reports for procedures performed between January 2022 and October 2025. A total of 44 patients underwent nephrectomy with an open or laparoscopic technique. Inclusion criteria: (1) availability of complete laboratory and clinical records; (2) Accessible of operative report and follow-up data. Exclusion criteria: (1) Histopathology found to be malignant (RCC or Urothelial Carcinoma) or no Histopathology report found; (2) Incomplete clinical records or follow-up data.

Variables collected included age, gender, nutritional status (weight and height), preoperative laboratory values, including serum albumin concentration (g/dL) and inflammatory markers such as platelet count, lymphocyte count, and neutrophil count (cells/mm^3), comorbid factors (DM and hypertension), and ASA Physical Status Classification. Operative Report data were collected for the technique used, blood loss, and complications recorded. Follow-up data were collected for LOS and drain placement removal. Patients were followed for 1 month after the operation to record any complications or readmission needed for complications.

This study was conducted following approval from the Ethics Committee of Medical and Health Research Ethics Committee (MHREC), Faculty of Medicine, Public Health and Nursing Universitas Gadjah Mada – Dr. Sardjito General Hospital, with document approval

number KE-FK-0550-EC-2026. All procedures were performed in accordance with ethical standards and institutional regulations.

Risk factors of complications are accumulated and compared using statistical analysis performed using statistical software (SPSS version 25.0 or R version 4.0.0). p-value <0.05 is considered statistically significant. The cut off for hemoglobin is <12gr/dl, NLR is 3, and PLR is 149. And the cut-off for PNI is based on the mean data from this study. The analytical statistic method using chi-square or fischer exact test when minimal sample unmeet. Odds Ratios were used to determine the relationship between risk factors and complications.

RESULT

Table 1. Characteristics of Respondents (n=44)

Characteristics of Respondent	N	(%)
Age		
Adult	33	75
Child	11	25
Gender		
Male	12	27
Female	32	73
Risk Factor		
Diabetes Melitus	4	9
Hypertension	12	27
ASA		
1	5	11
2	37	84
3	2	5
BMI		
Normal	14	32
Underweight	12	27
Overweight	18	41
Operation Technique		
Open	14	30
Laparoscopy	30	68
Laboratorium		
High NLR	14	32
High PLR	27	61
Low PNI	38	86
Complication		
Complication intraoperation	3	7
Complication Post Operation	11	25

Table 2. Operation Report

Bleeding Volume	Mean value
Open	500cc
Laparoscopy	150cc
LOS	
Open	4.5 days
Laparoscopy	3 days
H-Drain	
Open	4 days
Laparoscopy	3 days

According to table 1 and 2, A total of 44 patients underwent nephrectomy, comprising 33 adult patients (75%) and 11 pediatric patients (25%), with a mean age of 38 years. The cohort was predominantly female, with 32 female patients (73%) and 12 male patients (27%). Comorbidity was calculated with hypertension found in 12 patients (27%), followed by diabetes mellitus in 4 patients (9%). Preoperative ASA classification showed that 37 patients (84%) were ASA 2, 5 (11%) ASA 1, and 2 (5%) ASA 3. Body mass index distribution showed that overweight patients were the largest group, at 18 patients (41%), followed by normal weight at 14 patients (32%) and underweight at 12 patients (27%).

Laparoscopic approach was the predominant surgical approach, performed in 30 patients (68%), while open approach was performed in 14 patients (30%). The laparoscopic approach resulted in significantly reduced intraoperative bleeding volume (mean 150 cc) compared with open nephrectomy (mean 500 cc), representing a 73% reduction in blood loss. Intraoperative complications occurred in only 3 patients (7%), while postoperative complications were observed in 11 patients (25%).

Elevated neutrophil-to-lymphocyte ratio (NLR) was found in 14 patients (32%), elevated platelet-to-lymphocyte ratio (PLR) in 27 patients (61%), and low prognostic nutritional index (PNI) in 38 patients (86%). High prevalence of low PNI indicates significant nutritional depletion in the majority of this study.

Length of hospital stay presented differences between surgical approaches. The overall mean LOS was 3.75 days; open nephrectomy patients had a median LOS of 4.5 days, whereas laparoscopic nephrectomy patients had a shorter median LOS of 3 days (33% reduction). Intra-abdominal drain duration varies across techniques, with a mean of 4.21 days overall. The open approach had a median drain placement of 4 days, while the laparoscopic approach had drains removed sooner, with a median time of 3 days (25% reduction). The data collectively demonstrate that the laparoscopic approach offers substantial perioperative advantages, including reduced intraoperative bleeding, shorter hospital stay, and earlier drain removal, compared to open nephrectomy.

Table 3. Analysis of factors associated with perioperative complications

Variables	Complications (+)		Complications (−)		OR (95% CI)	p-value
	n	%	n	%		
Surgical technique						
Open	7	50.0	7	50.0	4.00 (1.01-15.86)	0.049
Laparoscopic	6	20.0	24	80.0		
NLR						
High	3	21.4	11	78.6	0.55 (0.12-2.41)	0.332
Normal	10	33.3	20	66.7		
PLR						
High	4	20.0	16	80.0	0.42 (0.11-1.64)	0.175
Normal	9	37.5	15	62.5		
PNI						
Low	11	28.9	27	71.1	0.82 (0.13-5.11)	0.583
Normal	2	33.3	4	66.7		
Hypertension						
Yes	3	25.0	9	75.0	0.73 (0.16-3.30)	0.496
No	10	31.3	22	68.8		
Diabetes mellitus						
Yes	0	0	4	100.0	-	0.232
No	13	32.5	27	67.5		
BMI						
Underweight	9	64.3	5	35.7	11.70 (2.57–53.36)	0.001
Non-underweight	4	13.3	26	86.7		
Preoperative anemia						
Yes	11	48.7	12	52.2	8.71 (1.64-46.31)	0.006
No	2	9.5	19	90.5		
ASA						
≥3	1	33.3	2	66.7	1.21 (0.10-14.62)	0.661
<3	12	29.3	29	70.7		

Bivariate analysis demonstrated associations between most independent variables and perioperative complications (intra- and postoperative) (Tables 1 and 2). Between the 44 patients, 14 patients (32%) experienced complications (either intraoperative or postoperative).

Surgical technique was statistically significantly associated with perioperative complications (p = 0.049). Open nephrectomy had a higher complication rate, with 7 of 14 patients (50%) experiencing complications compared to only 6 of 30 patients (20%) undergoing laparoscopic nephrectomy. The odds ratio of 4.0 means that open nephrectomy surgery was four times more prone to perioperative complications than laparoscopic surgery, showing the value of the minimally invasive procedure in this group.

Preoperative anemia status was statistically significantly associated with perioperative complications (p = 0.006), with an odds ratio of 8.7. Among patients with preoperative anemia, 11 of 23 (48%) developed complications, whereas only 2 of 21 (10%) without anemia did.

Body mass index classification was another significant factor associated with complications (p = 0.001). Specifically, underweight patients were found to have much higher

rates of complications than patients who were not underweight. Nine out of 14 (64%) underweight patients had complications, while only 4 out of 30 non-underweight patients (13%) did. The odds ratio of 11.7 found in this study is the strongest association seen in this study, indicating that people who were underweight had an 11.7-fold increased risk of perioperative complications. This finding emphasizes that adequate nutritional reserves and appropriate body weight status are associated with surgical outcomes.

Hematologic or nutritional inflammatory markers were not statistically significantly associated with perioperative complications. Elevated neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) showed no association with complications ($p = 0.332$ and 0.175). Similarly, low prognostic nutritional index (PNI) did not achieve statistical significance in predicting complications ($p = 0.583$), despite the high overall prevalence of low PNI in this study.

Comorbid medical conditions, including hypertension ($p = 0.496$) and diabetes mellitus ($p = 0.232$), showed no statistically significant association with perioperative complications. Notably, no complications occurred among patients with preoperative diabetes mellitus (0 of 4 diabetic patients), although the small sample size limited statistical power for this analysis. American Society of Anesthesiologists (ASA) risk classification did not demonstrate significant association with complications ($p = 0.661$, OR = 1.2), with comparable rates between ASA ≥3 and ASA <3 groups.

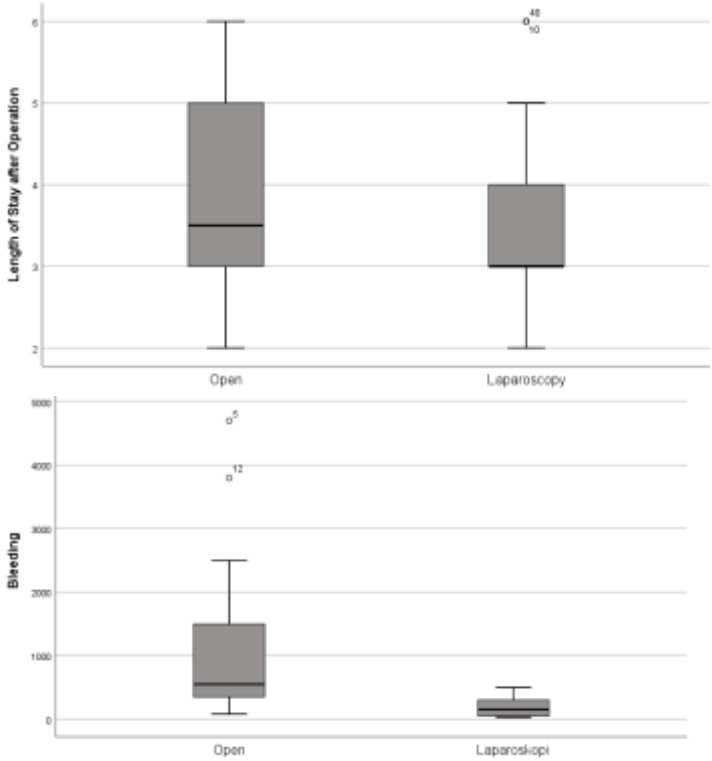

Figure 1. Boxplot for LOS and Bleeding Volume

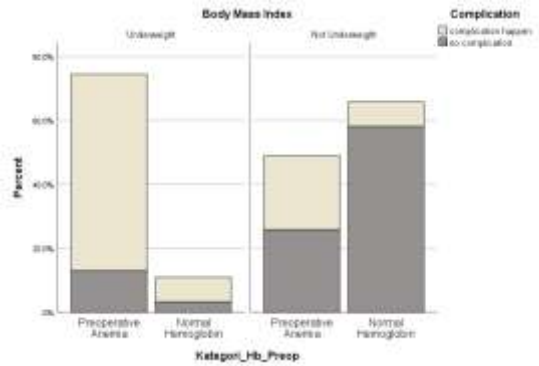

Figure 2. preoperative anemia and underweight status in complication prevalences

DISCUSSION

Laparoscopic nephrectomy in this study showed perioperative advantages over the open approach. The laparoscopic approach has a 73% reduction in intraoperative blood loss (150 vs. 500 mL) and a shorter median length of stay (3 vs. 4.5 days), mirroring recent large-scale comparative studies showing that laparoscopic nephrectomy consistently reduces blood loss, transfusion requirements, and hospitalization duration compared with the open approach. Open nephrectomy was associated with a fourfold higher odds of cumulative intra- and postoperative complications (OR 4.0, p = 0.049), which is directionally consistent with recent comparative literature reporting significantly higher overall complication and readmission rates after open nephrectomy compared to laparoscopic approaches. This is in line with the current series supporting the protective effect of the laparoscopic approach, and these converging data suggest that, when anatomically and technically feasible, laparoscopic nephrectomy should be preferred as the standard approach, particularly in patients in whom minimizing blood loss and hospital stay is clinically relevant (Alsmadi et al., 2025; Chiancone et al., 2023; J. Shah et al., 2024; Kierstan et al., 2020).

Beyond surgical technique, this study emphasizes the central importance of patient-related factors, particularly preoperative anemia and underweight nutritional status, in determining perioperative risk. Preoperative anemia was strongly associated with complications (OR 8.7, p = 0.006), with almost half of anemic patients developing complications compared to one-tenth of non-anemic patients. Similarly, underweight BMI emerged as the strongest predictor of complications (OR 11.7, p = 0.001), with 64% of underweight patients affected. Anemia and underweight status is a chronic condition that make the body already in catabolic condition, when the body undergo surgery, it would go in stress condition and causing systemic inflammatory responds that shifts the body into a catabolic state, and the body that already in less nutrition cannot handle the anabolic stress and lack of

hemoglobin will cause deprivation of oxygen for transferring energy to the body cell causing body prone to complication and less adaptive to regenerate. These complement a recent study showing that anemia is an independent predictor of adverse outcomes and recovery after surgery, and the impact of low BMI, sarcopenia, and poor body composition on postoperative morbidity and recovery in urologic and oncologic surgery (Ali et al., 2022; Kott et al., 2020; Li et al., 2022).

PNI, PLR, and NLR are used to detect systemic conditions through inflammatory markers. In chronic illnesses, lymphocyte counts decrease, while neutrophils participate in both acute and chronic immune responses; therefore, NLR and PLR levels tend to be higher in chronic cases. PNI indicates the body's nutritional reserves and immune response, reflecting how well it copes with chronic conditions. In this study, a high prevalence of low PNI was observed (86%), and inflammatory markers like NLR and PLR were often abnormal. However, they did not show significant links to complications, likely due to the small sample size from this single-center cohort (Goksen & Arslan, 2025; Li et al., 2022; Zhou & Luo, 2022).

This study has several limitations. First, it's a retrospective, single-center cohort study conducted at a tertiary referral hospital in Indonesia, which may limit the generalizability of the findings. Second, the predominance of laparoscopic procedures may limit the generalizability of the observed laparoscopic advantage across centers with varying levels of minimally invasive experience. Third, laboratory values were assessed only at baseline, and dynamic changes over the course of the disease were not evaluated. Future prospective multicenter studies with larger sample sizes, the same number of technical approaches, and serial monitoring of laboratory values are warranted to validate these findings.

These risk factors were easily detected and available from routinely checked laboratory values, making their integration into preoperative risk stratification feasible, and patients should undergo optimization in the perioperative setting prior to surgery. These findings support a multimodal perioperative strategy combining minimally invasive surgical techniques with structured preoperative optimization of anemia and nutritional status to reduce complication risk and improve recovery trajectories.

CONCLUSION

To summarize this study, the laparoscopic approach confers substantial perioperative benefits, including lower blood loss, shorter LOS, and days of drain placement. Patient factors that demonstrate significant prognostic factors are preoperative anemia and underweight BMI, with odds ratios exceeding those associated with surgical technique. When integrated with

current literature, these results support a risk-stratified model of care in which combining minimally invasive techniques with proactive, patient-centered optimization, particularly for those who are underweight or anemic, has the potential to improve perioperative outcomes in nephrectomy populations.

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