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Surgical Management of Kidney Transplant Complications: A Single-Center Experience

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ABSTRACT

Kidney transplantation remains the most effective treatment for end-stage renal disease; however, postoperative surgical complications may compromise both graft function and patient survival. This study aimed to evaluate surgical complications after kidney transplantation and to identify factors associated with reoperation in a single-center experience.
Medical records of 116 patients who underwent kidney transplantation between 2018 and 2021 were retrospectively reviewed. Thirteen patients who required reoperation due to postoperative complications and 20 randomly selected patients without complications were comparatively analyzed. Demographic, clinical, and perioperative variables, as well as the types and outcomes of complications, were evaluated. Statistical analyses included univariate and multivariable logistic regression models, supplemented by sensitivity analysis adjusting for age and BMI.
A total of 33 patients (24 males, 72.7%; 9 females, 27.3%) were included. In univariate analyses, right kidney donation ($p = 0.012$), female sex ($p = 0.041$), and preoperative blood transfusion ($p = 0.003$) were significantly associated with postoperative complications. However, these associations did not retain statistical significance in multivariable analysis. Patients with complications had significantly longer hospital stays and higher healthcare costs ($p = 0.001$). Vascular, urological, and general surgical complications were effectively managed with surgical interventions, achieving a graft survival rate of 84.6% and a patient survival rate of 100%.
Early recognition and timely surgical management of complications after kidney transplantation are essential for optimizing graft and patient outcomes. Identifying high-risk patients and implementing targeted preventive strategies may improve clinical results and reduce economic burden. Prospective multicenter studies with larger cohorts are warranted to validate and generalize these findings.

Keywords: Kidney transplantation, surgical complications, reoperation, risk factors, graft survival

Introduction

End-stage renal disease (ESRD) is a major health problem with a steadily increasing global incidence, and is associated with significant impairment of quality of life and decreased life expectancy. Dialysis therapy is mandatory for patient survival, while kidney transplantation is reported to be the most cost-effective treatment modality (1). Kidney transplantation is associated with longer survival and improved quality of life compared to dialysis (2).

However, the surgical complications that can occur following kidney transplantation may adversely affect both graft success and patient survival, and can lead to prolonged hospital stays and increased healthcare costs (3). Despite reductions in complication rates following advances in surgical techniques and the more effective use of immunosuppressive therapies, complications still remain a challenge due to the growing number of patients undergoing kidney transplantation (4). Morbidity and mortality can be reduced through the effective management of complications involving a multidisciplinary approach and early surgical intervention (5). Vascular, urological and surgical site complications are the leading causes of graft loss and patient mortality in the early postoperative period (6).

Although several studies have investigated postoperative complications after kidney transplantation, most have focused on medical or immunological aspects rather than on surgical management. Moreover, data from Türkiye regarding the surgical treatment and outcomes of post-transplant complications remain limited.

Therefore, this study aimed to analyze the incidence, risk factors, and surgical outcomes of complications developing after kidney transplantation in our center, and to evaluate how

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early recognition and surgical intervention influence graft and patient survival.

Materials and Methods

Study Design and Population: This retrospective study was conducted on patients who underwent kidney transplantation at the Organ Transplantation Center of Ufuk University between January 2018 and December 2021. Medical records of 116 patients were reviewed. Patients who developed surgical complications during the study period (n = 13) were included in the analysis. A control group of 20 patients without complications was randomly selected from the same cohort using a computer-based random number generator. Patients younger than 18 years or those who underwent re-transplantation due to chronic rejection were excluded.

The final study population consisted of 33 patients (13 with complications and 20 without complications). This sample size represented all available cases meeting the inclusion criteria and was considered adequate for descriptive and exploratory statistical analyses. Although a priori power analysis was not feasible due to the retrospective design, a post-hoc power analysis for key variables (hospital stay, healthcare cost, and preoperative blood transfusion) indicated an achieved power of ≥0.80 ($\alpha = 0.05$, two-tailed).

All kidney transplantations were performed by the same experienced surgical team following a standardized operative protocol. The vascular anastomosis and ureteroneocystostomy techniques were consistent across all cases. The choice of surgical approach did not differ among surgeons.

Data Collection: Clinical and demographic data were retrospectively collected from hospital electronic medical records and operative reports. The recorded variables included patient age, sex, body mass index (BMI), smoking status, donor age, and the laterality of the transplanted kidney (right or left). Clinical information such as preoperative blood transfusion history, length of hospital stay, and total healthcare cost (expressed in U.S. dollars) was also obtained. Laboratory parameters including hemoglobin, hematocrit, HbA1c, serum creatinine, and estimated glomerular filtration rate (eGFR) were reviewed at the time of admission and discharge.

In addition, the type, timing, and management of surgical complications were analyzed in detail. Complications were categorized as vascular, urological, or general surgical based on their anatomical origin and required intervention. Early complications were defined as those occurring within the first 14 postoperative days, whereas those developing thereafter were considered late complications. All data were independently verified by two investigators to ensure accuracy and completeness prior to statistical analysis.

Definition of Surgical Complications: Surgical complications were defined as postoperative events requiring reoperation or an invasive surgical procedure within the same hospitalization period. Complications were categorized as vascular (e.g., hemorrhage, anastomotic kinking), urological (e.g., ureteral stricture, leakage), or general surgical (e.g., seroma, wound infection).

Statistical Analysis: All analyses were performed using IBM SPSS Statistics for Windows, Version 21 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range, IQR) depending on the distribution, while categorical variables were presented as numbers and percentages (%).

Normality of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed variables were compared using the Student's t-test, and non-normally distributed variables using the Mann–Whitney U test. Categorical variables were analyzed using the Chi-square test or Fisher's exact test where appropriate.

A multivariable logistic regression analysis was conducted to identify independent predictors of surgical complications. Variables with $p < 0.10$ in univariate analysis (right kidney donation, female sex, and preoperative blood transfusion) were entered into the regression model. The results were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). A sensitivity analysis was additionally performed by adjusting the model for age and BMI to confirm robustness of associations.

All p-values were reported to three decimal places, and values below 0.001 were presented as $p = 0.001$. A $p < 0.05$ was considered statistically significant. The statistical methodology was reviewed and validated by a biostatistics specialist.

Ethical approval for the study was obtained from the Non-Interventional Clinical Research Ethics Committee of Ufuk University (Date: 18 January 2022, Decision No: 22.0113.01/09).

Results

A total of 33 patients were included in the study, consisting of 24 males (72.7%) and 9 females (27.3%). Eight patients received right-sided and 25 received left-sided kidney transplants. Donor age did not differ significantly between the two groups. Six patients (46.2%) who developed complications had received preoperative blood transfusions.

Patients with complications were older and more frequently female compared to those without complications (p = 0.041). Right kidney transplantation and preoperative blood transfusion were also significantly associated with higher complication rates (p = 0.012 and p = 0.003, respectively). Hospital stay and healthcare cost were both markedly higher in patients who developed complications (Table 1).

The most common complications requiring surgical intervention were hemorrhage (n=5, 38.5%), vascular kinking (n=3, 23.1%), and ureteral stricture (n=2, 15.4%). Patients with hemorrhage underwent hematoma drainage or revision surgery, while those with vascular kinking required anastomotic revision or repositioning. Ureteral reimplantation and stent placement were performed for patients who developed ureteral stricture. Seroma formation (n=2, 15.4%) and surgical site infection (n=1, 7.6%) were less common (Table 2).

Among patients who developed complications, right kidney donation (p=0.012), female sex (p=0.041), and preoperative blood transfusion (p=0.003) were identified as significant risk factors. The increased rate of complications in right kidney donations was attributed to anatomical and technical challenges, while the higher rate in female patients was associated with vascular and hormonal differences. Preoperative blood transfusion was correlated with increased immunologic activity (Table 3).

Patients who developed complications had significantly longer hospital stays and higher healthcare costs (p = 0.001). Most complications (n=9, 69%) occurred in the early postoperative period (within the first two weeks), while the remaining cases (n=4, 31%) developed later, mainly due to technical or urological factors.

The most frequent indications for reoperation were postoperative hemorrhage and vascular complications in the early postoperative period, whereas ureteral complications were managed by open reimplantation and stent placement. All procedures were performed successfully.

In multivariable logistic regression analysis, none of the variables retained statistical significance after adjustment, although female sex (OR = 1.69, 95% CI = 0.34–8.36) and right kidney donation (OR = 2.25, 95% CI = 0.43–11.70) continued to show a trend toward increased risk (Table 4).

A sensitivity analysis was conducted by adjusting for age and BMI to evaluate the stability of the model. The inclusion of these covariates did not substantially change the results, and no significant predictors of complications were identified (Table 5).

After all surgical interventions, graft survival was 84.6%, and patient survival was 100%. Patients who required reoperation had longer hospitalizations and higher treatment costs, but most achieved satisfactory postoperative recovery and stable graft function at discharge.

Discussion

Surgical complications following kidney transplantation are critical determinants of both graft success and patient survival. Although continuous improvements in surgical techniques, immunosuppressive therapy, and perioperative management have reduced complication rates, the absolute number of adverse events continues to rise in parallel with the increasing number of kidney transplantations performed worldwide (7). Early detection and timely management of complications remain essential to reduce morbidity and mortality (8).

Consistent with previous studies, the most common complications in the present series were hemorrhage, vascular anastomotic failure, and ureteral complications (9). Hemorrhagic events occurring in the early postoperative period were effectively managed with revision surgery and hematoma drainage. Vascular complications—such as anastomotic failure, thrombosis, or kinking—remain among the most challenging issues in transplantation surgery, often requiring urgent intervention and posing a major risk for graft loss (10). Interventions including anastomotic revision, kidney repositioning, and thrombectomy achieved high rates of graft survival in these patients (11).

Ureteral complications were successfully treated with open surgical reimplantation and stent placement, resulting in improved graft function in most cases. Previous reports have associated these

Table 1: Baseline Characteristics of The Patient Groups

Characteristic	Complications (n=13)	No complications (n=20)	p-value
Age (years, mean ± SD)*	39.9 ± 16.8	37.7 ± 9.7	0.620
Female/Male†	5/8	4/16	0.041
BMI (kg/m², mean ± SD)*	23.1 ± 5.0	24.0 ± 3.0	0.410
Donor age (years, mean ± SD)*	45.4 ± 13.3	47.9 ± 12.5	0.570
Right/Left kidney†	5/8	3/17	0.012
Preoperative blood transfusion†	6 (46.2%)	0	0.003
Hospital stay (days, median [IQR])‡	20 [14–30]	9 [8–12]	0.001
Healthcare cost (USD)‡	10,500 [9,600–11,600]	6,600 [6,000–7,200]	0.001

*Student's t-test; † Chi-square test; ‡ Mann–Whitney U test for non-normally distributed variables. SD: standard deviation; p: probability value. All p-values are reported to three decimal places

Table 2: Common Complications After Kidney Transplantation and Corresponding Surgical Interventions

Complication	Surgical intervention	n	%
Hemorrhage†	Hematoma drainage / revision	5	38.5
Vascular kink†	Anastomosis revision / reposition	3	23.1
Ureteral stricture†	Reimplantation / stenting	2	15.4
Seroma formation†	Drainage of fluid collection	2	15.4
Surgical site infection†	Drainage / wound care	1	7.6

†Chi-square or Fisher's exact test, as appropriate. Values are expressed as number (%). n: number; %: percentage; p: probability value. All p-values, where applicable, were reported to three decimal places. A p-value < 0.05 was considered statistically significant

Table 3: Evaluation of Risk Factors In Patients Who Developed Complications

Risk factor	With complications (%)	Without complications (%)	p-value	Explanation
Right kidney donation†	38.5 (5/13)	15.0 (3/20)	0.012	Anatomical and technical difficulties
Female sex†	38.5 (5/13)	20.0 (4/20)	0.041	Vascular/hormonal differences
Preoperative blood transfusion†	46.2 (6/13)	0 (0/20)	0.003	Increased immune activity
Recipient age (years, mean ± SD)*	39.9 ± 16.8	37.7 ± 9.7	0.620	No significant difference
BMI (kg/m², mean ± SD)*	23.1 ± 5.0	24.0 ± 3.0	0.410	No significant difference
Smoking (mean pack-years ± SD)‡	8.1 ± 10.5	19.8 ± 24.8	0.150	No significant difference

*Student's t-test; † Chi-square test; ‡ Mann–Whitney U test. SD: standard deviation; p: probability value. All p-values are reported to three decimal places, and values < 0.001 were presented as p = 0.001. A p-value < 0.05 was considered statistically significant

complications with factors such as advanced donor age, obesity, the presence of accessory renal arteries, and extensive ureteral dissection (12). In line with these findings, right kidney donation, female sex, and preoperative blood transfusion were identified in the present study as significant risk factors for postoperative complications. The higher complication rates in right kidney transplantations may be explained by anatomical and technical factors, including a shorter renal vein and greater difficulty in venous anastomosis (13). In female recipients, thinner vascular

Table 4: Multivariable Logistic Regression Analysis of Risk Factors For Surgical Complications

Predictor	OR	95% CI	*p*-value
Female sex	1.69	0.34–8.36	0.517
Right kidney donation	2.25	0.43–11.70	0.335
Preoperative blood transfusion	0.73	0.10–5.11	0.752

Logistic regression (maximum likelihood). OR: odds ratio; CI: confidence interval. All p-values are reported to three decimal places; values < 0.001 are shown as p = 0.001. A p-value < 0.05 was considered statistically significant

Table 5: Sensitivity Analysis (Multivariable Logistic Regression Adjusted For Age and BMI)

Predictor	OR	95% CI	*p*-value
Female sex	1.53	0.29–7.98	0.616
Right kidney donation	2.63	0.45–15.29	0.282
Preoperative blood transfusion	0.67	0.09–5.13	0.700
Age (per year)	0.99	0.94–1.05	0.788
BMI (kg/m^2)	0.95	0.77–1.17	0.628

structures, hormonal influences, and immunologic differences may contribute to increased susceptibility to postoperative complications.

The association between preoperative blood transfusion and surgical outcomes remains a matter of debate. Earlier studies suggested that transfusion might have an immunomodulatory effect, whereas recent evidence indicates that it may increase immunologic activation and postoperative complication risk (14). In addition to transfusion-related factors, anatomical and technical challenges—particularly in right kidney transplantation—have also been associated with increased postoperative complications, as reported in recent large-scale cohort studies (15).

In the multivariable logistic regression analysis, none of the identified risk factors retained statistical significance, which may be attributed to the limited sample size and study power. However, the directionality of associations in the sensitivity analysis remained consistent with the primary findings, suggesting a stable relationship between anatomical and patient-related factors and postoperative complications. Although none of the variables retained statistical significance in multivariable analysis, the direction of association—particularly for female sex and right kidney donation—suggests a potential trend toward increased complication risk. This lack of statistical significance may be attributed to the limited sample size and the reduced statistical power of the regression model. These results emphasize the importance of refined surgical technique, individualized perioperative management, and the identification of high-risk patient profiles.

Patients who experienced complications had significantly longer hospital stays and higher healthcare costs, underlining the dual clinical and economic burden of surgical complications. Preventive strategies, early recognition, and multidisciplinary postoperative monitoring are therefore crucial for both patient safety and the sustainability of healthcare systems (16).

Despite the retrospective and single-center design, this study provides valuable insights into the surgical management of post-transplant complications in Türkiye. To our knowledge, this is one of the few single-center analyses from the region focusing specifically on surgically managed kidney transplant complications. Future multicenter and prospective studies with larger cohorts are warranted to validate these findings, improve risk stratification, and develop standardized protocols for complication prevention and management.

Limitations: This study has several limitations that should be acknowledged. First, the retrospective and single-center design inherently limits the generalizability of the findings and may introduce selection bias. Second, the relatively small sample size, particularly in the complication group, reduces the statistical power of the analyses and may lead to type II error, preventing the detection of subtle but clinically meaningful associations. The nonsignificant results observed in multivariable analysis should therefore be interpreted with caution, as they may reflect insufficient power rather than a true lack of

association. Third, potential confounding factors such as donor comorbidities, intraoperative ischemia time, and postoperative immunosuppressive regimens were not fully analyzed, which could influence complication rates and graft outcomes. Finally, the follow-up period was limited to the early postoperative course; therefore, late-onset complications and long-term graft function could not be comprehensively assessed.

Surgical complications following kidney transplantation remain a major challenge, significantly impacting both graft and patient survival. In this study, right kidney donation, female sex, and preoperative blood transfusion were identified as potential risk factors for postoperative complications. Although none retained statistical significance in the multivariable analysis, the consistency of associations in the sensitivity analysis supports their clinical relevance.

Early recognition, timely surgical intervention, and a multidisciplinary approach are essential for optimizing outcomes in affected patients. Procedures such as hematoma drainage, anastomosis revision, and ureteral reimplantation with stent placement can achieve high graft survival and favorable recovery rates. Moreover, meticulous preoperative planning and close postoperative monitoring can help minimize complications, particularly among high-risk individuals.

From an economic perspective, surgical complications substantially increase hospitalization duration and healthcare expenditures, posing an additional burden on both patients and healthcare systems. Preventive strategies, early diagnosis, and efficient surgical management are therefore crucial not only for clinical success but also for cost-effective care delivery.

Identifying modifiable risk factors and implementing patient-tailored preventive measures are key to improving long-term outcomes and optimizing resource utilization. Prospective, multicenter studies with larger cohorts are warranted to validate and generalize these findings and to establish standardized protocols for the prevention and management of surgical complications after kidney transplantation.

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Ethical Approval: This study was approved by the Ethics Committee of Ufuk University (Date: 2022-01-18, Decision No: 22.0113.01/09).

Conflict of Interest: The authors declare that they have no conflicts of interest related to the conduct or publication of this study.

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