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Correlation Between Early Postoperative Urine Output and One-Year Graft Function after Living Donor Kidney Transplantation: A Prospective Observational Study

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ABSTRACT

Introduction

The prognostic value of early postoperative urine output after kidney transplantation remains uncertain. This study evaluates its association with one-year graft function and examines additional clinical predictors.

Methods

A prospective observational study was conducted at a tertiary transplant center in 90 renal transplant recipients; 82 completed one-year follow-up. Primary outcome was one year estimated glomerular filtration rate (eGFR) by Chronic Kidney Disease Epidemiology Collaboration 2021. Exposures included urine output on postoperative days 1 to 3, donor age, warm and cold ischemia times, discharge creatinine, dialysis duration, human leukocyte antigen mismatch, and early surgical complications within 30 days. Primary analysis used linear regression with prespecified covariates. Secondary analysis used logistic regression for eGFR less than 60 mL per minute per 1.73 m^2.

Results

Urine output on postoperative days 1, 2 and 3 did not correlate with one year estimated glomerular filtration rate. Complications occurred in 8.5 % (7/82). Body mass index showed no association with one year estimated glomerular filtration rate. In the multivariable model, older donor age and higher discharge creatinine independently associated with lower one year estimated glomerular filtration rate (donor age B = -0.595, p = 0.02; discharge creatinine B = -0.219, p = 0.03). Single-marker receiver operating characteristic analysis showed poor discrimination.

Conclusion

Early post-operative urine output did not correlate with one-year graft function. Future research should focus on additional markers and strategies to improve graft function prediction.

Keywords

Chronic kidney disease; estimated glomerular filtration rate; living kidney donors; renal transplantation

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INTRODUCTION

A significant number of kidney allografts experience delayed graft function (DGF) or slow graft function (SGF), affecting 20–33% of deceased donor and 3–5% of living donor transplants.[1-4] These complications relate to factors such as prolonged cold ischemia time, donor quality, recipient age, comorbidities, and immune sensitization.[1,5,6] Urine output is a bedside correlate of DGF, which is linked to worse long-term outcomes, including higher healthcare costs, emotional stress, and reduced graft survival.[5,7-10]

Graft survival depends on pre- and peri-transplant factors like donor and recipient age, donor type, familial relationship, hemoglobin, dialysis duration, discharge creatinine, body mass index (BMI), and kidney laterality.[11,12] Post-transplant complications, notably cardiovascular events and infections from immunosuppression, also threaten graft longevity.[13]

Early postoperative markers may offer rapid insights into graft function. Urine output, an accessible clinical measure, is proposed as a predictor of favorable outcomes; higher urine output on the first postoperative day correlates with better graft function and survival.[14,15] While serum creatinine and glomerular filtration rate (GFR) monitor renal function, urine output remains an immediate, practical, but underused prognostic tool.[16,17]

No standardized postoperative urine output criteria exist to predict one-year renal function after transplantation. Establishing this link could enable early risk detection and timely interventions. Given its simplicity and low cost, urine output monitoring may improve post-transplant care, especially in resource-limited settings like Nepal, where data are scarce. This study aims to evaluate the relationship between postoperative urine output and one-year graft function, analyze recipient and donor demographics, classify complications by Clavien-Dindo, and assess recipient BMI's impact on graft outcome.

METHODS

This prospective, descriptive, quantitative study conducted over a two-year period at the Department of Urology and Kidney Transplant Surgery, Tribhuvan University Teaching Hospital (TUTH), Nepal. It included one year of data collection and an additional year of follow-up. Ethical approval was obtained from the Institutional Review Committee (IRC) of Institute of Medicine (IRC ref: 566 (6-11) E2), ensuring compliance with the Declaration of Helsinki and relevant ethical standards. All participants provided written informed consent after receiving detailed information regarding study objectives, methodology, and data confidentiality.

The study population included all end-stage renal disease (ESRD) patients undergoing kidney transplantation at TUTH during the study period. A convenience sampling approach was employed, enrolling all eligible transplant recipients. The

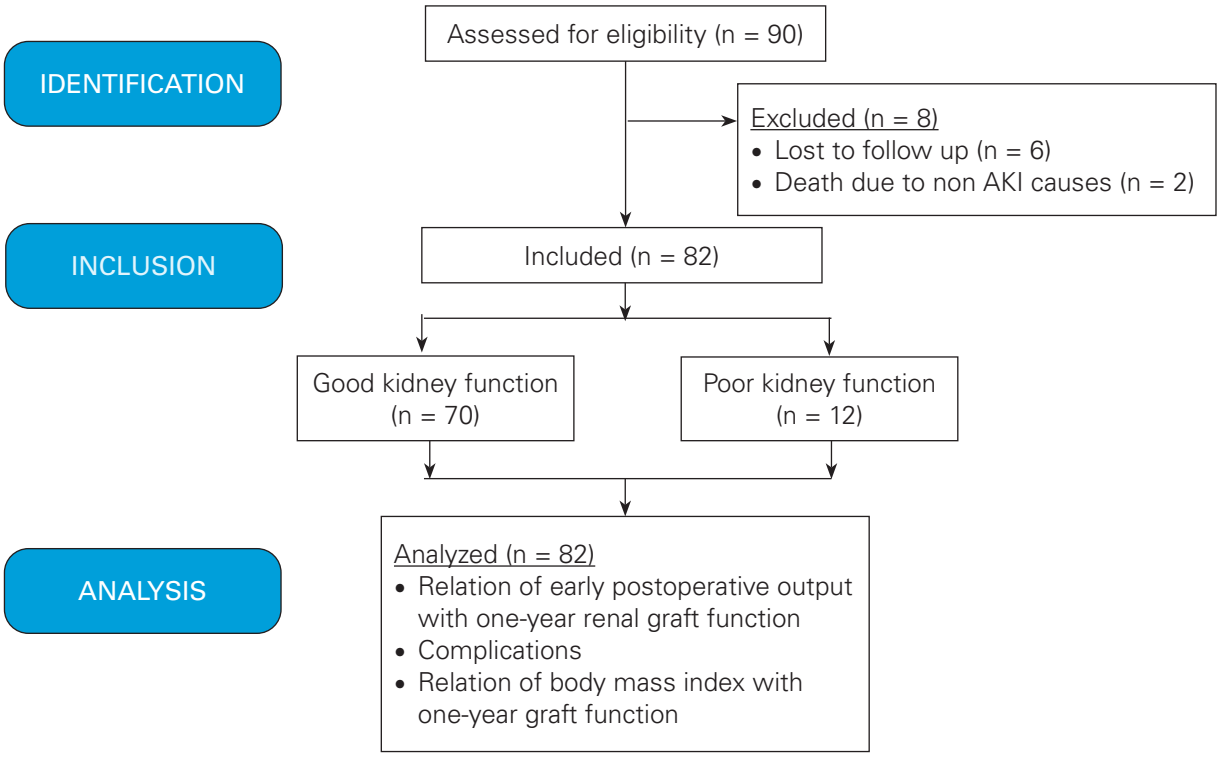

Figure 1. STROBE flow diagram

inclusion criteria comprised all kidney transplant recipients treated at the department within the study timeframe. Exclusion criteria were death from non-AKI causes, loss to follow-up, age younger than 18 years, or refusal of consent. The study collected data on recipient characteristics, including age, sex, blood group, relationship with donor, BMI, duration of dialysis, estimated glomerular filtration rate (eGFR), comorbidities such as hypertension and diabetes, post-operative complications, post-operative Doppler ultrasound findings of the graft kidney (including resistive index), urine output over three post-operative days, hemoglobin levels, and creatinine levels at discharge.

Donor characteristics were also analyzed, including donor age, sex, blood group, kidney size, comorbidities, and human leukocyte antigen (HLA) mismatch. Obesity included patient with BMI > 30kg/m^2. Early postoperative surgical complications were defined as events occurring within 30 days after transplantation and graded using the Clavien–Dindo classification. Follow-up data at one year post-transplantation included eGFR, calculated using the Chronic Kidney Disease Epidemiology Collaboration 2021, as a primary outcome measure. Good or poor kidney function was assessed at one year post transplant using an eGFR threshold of 60 mL/min/1.73 m^2.

Statistical analyses were conducted using International Business Machines Statistical Package for the Social Sciences Statistics (Version 26.0, IBM Corp., Armonk, NY, USA), with p-values <0.05 considered statistically significant. Patients were categorized into two groups: good and poor kidney function. Descriptive statistics summarized continuous variables as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages. Shapiro-Wilk test was used to assess normality. Statistical analysis was performed using the independent t-test for normally distributed continuous variables, the Mann-Whitney U test for non-normally distributed continuous variables, and Fisher's exact test for categorical variables. Relationships between continuous variables were evaluated using Pearson's correlation coefficient (for normally distributed data) or Spearman's rank correlation coefficient (for non-normally distributed data).

Multiple linear regression was used to identify independent predictors of one-year estimated glomerular filtration rate, incorporating donor age, duration of dialysis, HLA mismatch, ischemia times, post-operative urine output, and kidney size as independent variables. Receiver operating characteristic analysis was used to estimate the area under the curve for donor age and second warm ischemia time in classifying impaired one-year estimated glomerular filtration rate. The diagnostic performance was evaluated by calculating the Area Under the Curve (AUC), sensitivity, specificity, and 95% confidence intervals (CI). For this analysis, eGFR was dichotomized into two categories: normal function (≥60 mL/min/1.73m^2) and impaired function (<60 mL/min/1.73m^2).

RESULTS

Study population and baseline characteristics

During the study period, 90 kidney transplants were performed. Six patients were excluded due to loss to follow-up and 2 patients due to death within one year post-transplantation, leaving 82 patients for the final analysis. The mean age of recipients was 36.3 ± 11.1 years (range: 15–61 years). The majority were male (66; 80.5%), while female recipients accounted for 16 (19.5%). The

Table 1. Demographic data of kidney transplant recipients

Characteristics	Poor kidney function (n=12)	Good kidney function (n=70)	p value
Age (years)	34.08 ± 10.45	36.69 ± 11.21	0.46*
Sex (male/female)	9(75.0%)/ 3(25.0%)	57(81.42%)/ 13(18.58%)	0.69**
BMI (kg/m^2)	20.78 ± 4.70	21.34 ± 3.26	0.61*
Duration of dialysis (months)	8.0 (8.3)	12.50 (14.5)	0.84#
Preoperative creatinine	715.50 ± 192.879	658.00 ± 243.816	0.44*
Hypertension	12 (100%)	65 (92.85%)	1.00**
Diabetes	0 (0%)	6 (8.57%)	0.59**
Hypothyroidism	0 (0%)	10 (14.28%)	0.34**
Native kidney disease			0.74**
Chronic glomerulonephritis	8 (66.67%)	43 (61.42%)	
IgA Nephropathy	3 (25.0%)	12 (17.14%)	

** t-test, ** Fisher's exact test, # Mann Whitney U test*

Table 2. Demographic data of kidney donors and donated kidney

Characteristics	Poor kidney function (n=12)	Good kidney function (n=70)	p-value
Age (years)	54.17 ± 6.82	43.97 ± 10.74	0.002*
Sex (male/female)	2(16.67%)/ 10(83.33%)	24(34.28%)/ 46(65.72%)	0.32**
Donor kidney size (cm)	10.2 ± 0.7	10.2 ± 0.5	0.95*
HLA mismatch	2.0 (4)	3.0 (2)	0.11**

** t-test, ** Fisher's exact test*

most common blood group was B+ (17; 20.7%), and the predominant native kidney disease (NKD) was chronic glomerulonephritis (CGN) (49; 59.7%). The mean body mass index (BMI) was 21.3 ± 3.5 kg/m² (range: 13.7–31.0 kg/m²). The most frequent HLA mismatch was 2/6, observed in 27 patients (32.9%).

The mean duration of dialysis before transplantation was 9 months, with hypertension (HTN) being the most common comorbidity (59; 71.9%). Donor age ranged from 23 to 65 years, with a mean of 45.5 ± 10.9 years. The spouse was the most common living donor (24; 29.2%). The mean renal allograft size was 10.63 ± 0.49 cm.

Postoperative complications

In our study, complications were observed in 7 (8.5%) patients. Urinary retention (Clavien Dindo Grade II) was managed conservatively with Foley catheterization and alpha blockers in one patient with benign prostatic enlargement. A urinary tract infection (UTI) with persistent proteinuria (Clavien Dindo Grade II) was reported in one case. Prolonged drain output (lymphorrhoea) was observed in two patients, requiring close monitoring. Accidental drain removal occurred in one patient, which was managed with serial imaging. Surgical re-exploration (Clavien Dindo Grade IIIb) was required in two cases due to hemorrhage and hemodynamic instability, necessitating drainage and intensive monitoring.

Demographic and perioperative comparisons

Recipient demographics did not differ significantly between the two groups (Table 1). However, donor age showed a statistically significant difference between groups (Table 2). Among perioperative parameters, only second WIT demonstrated a significant difference, while other parameters remained comparable (Table 3).

One-year eGFR and postoperative urine output

Postoperative urine output on days 1, 2, and 3 was comparable between groups (Table 4). Given the non-normal distribution of urine output, Spearman's correlation was used to assess its relationship with eGFR at one year. No significant correlation was observed (all $p > 0.05$). The overall model accounted for only 1.7% of the variance in eGFR ($R^2 = 0.017$, $p = 0.72$), indicating a weak predictive ability.

Comparison of one-year eGFR with recipient, donor, and perioperative parameters

Other clinical factors, including body mass index

Table 3. Perioperative parameters

Characteristics	Poor kidney function (n=12)	Good kidney function (n=70)	p-value
First warm ischemia time (min)	8.0 (5)	7.0 (5)	0.69#
Cold ischemia time (min)	34.5 (32)	40.0 (17)	0.30#
Second warm ischemia time (min)	56.17 ± 14.54	44.87 ± 8.921	0.02*
Length of hospital stay (days)	9.67 ± 1.23	10.47 ± 2.49	0.28*

** t-test, #Mann Whitney U test*

Table 4. Urine output

Post-op Day	Urine output (ml)		p-value
	Poor kidney function (n=12)	Good kidney function (n=70)	
POD1	14842.50 (6859)	13845.0 (7901)	0.74#
POD2	11025.50 (6871)	10827.0 (5894.785)	0.30#
POD3	8071.50 (2459)	7387.50 (2805)	0.21#

#Mann Whitney U test

Table 5. Multivariate analysis

Variable	B (Unstandardized Coefficient)	Beta (Standardized Coefficient)	p-value
Age	0.295	0.158	0.27
Sex	-4.414	-0.085	0.53
BMI	-1.272	-0.214	0.14
Native Kidney Disease (NKD)	-1.076	-0.067	0.56
Duration of Dialysis	-0.065	-0.051	0.71
HLA Mismatch	-0.878	-0.068	0.61
Duration of Stay	0.339	0.039	0.75
Pre-transplant UO (ml)	0.001	0.023	0.87
First Warm Ischemia Time	0.288	0.050	0.69
Cold Ischemia Time	0.065	0.099	0.53
Second Warm Ischemia Time	-0.250	-0.128	0.26
Post-op Complications (POP Cx)	-1.037	-0.088	0.48
Pre-op Creatinine	-0.002	-0.018	0.90
Creatinine at Discharge	-0.219	-0.313	0.03
Donor Age	-0.595	-0.312	0.02
Donor Sex	-8.274	-0.187	0.14
Donor Relation	-0.547	-0.088	0.58
Donated Kidney Size (cm)	-2.326	-0.058	0.61

(BMI), dialysis duration, HLA mismatch, ischemia times, and kidney size, did not demonstrate a significant correlation with eGFR at one year. However, donor age exhibited a significant negative correlation with eGFR ($r = -0.364$, $p = 0.001$), suggesting that higher donor age was associated with lower post-transplant renal function. Additionally, second WIT was negatively correlated with eGFR ($r = -0.247$, $p = 0.03$), indicating that prolonged ischemia adversely affected long-term kidney function.

Multivariate analysis

A multivariate regression model identified two independent correlates of one-year estimated glomerular filtration rate.:

Donor age: B = -0.595, p = 0.02

Serum creatinine at discharge: B = -0.219, p = 0.03

Second warm ischemia time was not independently associated after adjustment: unstandardized B = −0.250, standardized beta = −0.128, p = 0.26.

Correlation of donor age and serum creatinine at discharge with one-year eGFR

Receiver operating characteristic analysis assessed single-marker discrimination for one-year function status.

- Area under the curve for second warm ischemia time = 0.251.
- Area under the curve for donor age = 0.213.

These areas under the curve indicate discrimination worse than chance, reflecting inverse orientation relative to the poor-function class.

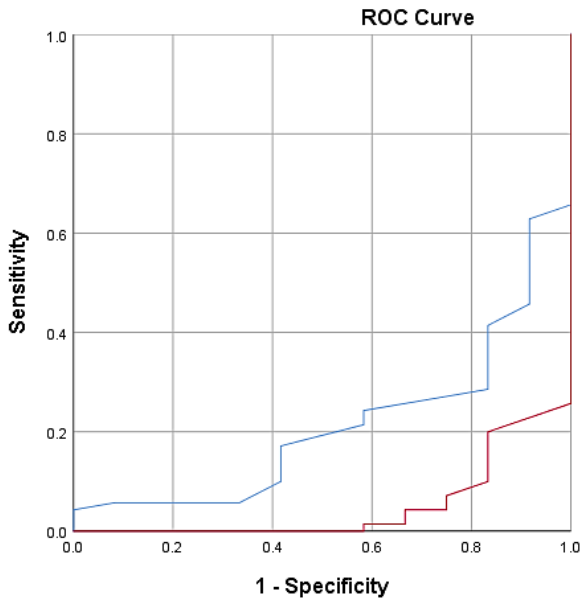

Figure 2. ROC analysis

DISCUSSION

Early postoperative urine output is often considered a favorable sign of renal graft function following kidney transplantation. Nonetheless, the association between initial diuresis and long-term graft survival remains uncertain.[18] This study provides key insights into the relationship between early postoperative urine output and long-term renal function in living donor kidney transplant recipients. Our findings suggest that urine output in the immediate postoperative period does not significantly predict one-year eGFR.

Our results contrast with Lai et al. (2010), who found that urine output on day 7 (UO7) strongly predicted one-year graft function. The discrepancy may stem from differences in urine output measurement timing and donor types, as their study focused on deceased donors, whereas ours included only living donors.[19] Similarly, while Kim et al. (2019) found no significant association between early urine output and eGFR in living donor transplants, they reported a strong correlation in deceased donor recipients, further supporting the role of ischemia-reperfusion injury in influencing long-term renal outcomes.[20]

Our findings align with Tillou et al. (2013) in recognizing urine output as an important marker in transplantation, but with different predictive values. Tillou et al. found that pre-transplant anuria was associated with poorer graft survival, whereas our study suggests that immediate postoperative diuresis does not reliably indicate long-term function. This distinction reinforces the idea that pre-transplant bladder function and surgical risks may have a greater impact on outcomes than early postoperative urine output alone.[21]

In our cohort, mean body mass index was 21.3 ± 3.5 kg/m² (n = 82). Among them, 1.25% being obese, which limited powered groupwise contrasts. On univariable linear regression, each +1 kg/m² was associated with −1.59 mL/min/1.73 m² lower one-year estimated glomerular filtration rate. Obesity (≥ 30 kg/m²) was 1/82 (1.2%), limiting powered groupwise contrasts. In contrast, study by Bosma et al. (2007) found mean body mass index 26 ± 4 kg/m² with 13% of them being obese. In adjusted models, body mass index was associated with higher GFR ($p<0.001$) and higher filtration fraction ($p=0.038$). Differences likely explain the opposite directionality versus our lean living-donor cohort: measured GFR vs Chronic Kidney Disease Epidemiology Collaboration estimated GFR, higher body mass index distribution and predominantly deceased donors.[22]

In our cohort, early postoperative complications occurred in 7 of 82 recipients (8.5%). One-year estimated glomerular filtration rate was 75.1 ± 16.5 mL/min/1.73 m² in recipients with complications versus 78.7 ± 21.4 mL/min/1.73 m² in those without; the mean difference was −3.6 mL/min (Welch $t = -0.67$; $p = 0.515$). Thus, early complications were not associated with a clinically meaningful decrement in one-year function. By comparison, Minkovich et al. (2024) reported 30-day surgical complications in 24.7% of 1,334 recipients, most commonly perigraft collections (66.8%). On adjusted analyses, the presence of any complication was not independently associated with one-year estimated glomerular filtration rate, while higher Clavien grades primarily predicted readmission. The higher crude complication rate in that study likely reflects its larger sample size and systematic 30-day event capture.[23]

Limitations of this study included single center design and small sample size. Early urine output was influenced by non-standardized perioperative fluids and diuretics, potentially attenuating associations. Time varying factors such as rejection, infections, and calcineurin inhibitor exposure were not modeled, leaving residual confounding.

These findings indicate that although donor age and second warm ischemia time are statistically significant correlates of one year estimated glomerular filtration rate, their standalone value for clinical risk stratification is limited.

CONCLUSION

This study showed early postoperative urine output did not predict one-year graft function. Receiver operating characteristic analysis showed poor single-parameter discrimination, including donor age, indicating limited stand-alone clinical utility. Post-transplant assessment should rely on multifactorial risk profiling rather than single immediate postoperative measures, and future work should evaluate additional clinical and biomarker predictors while targeting modifiable ischemic and donor related factors.

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CONFLICT OF INTEREST

The author(s) declare that they do not have any

conflicts of interest with respect to the research, authorship, and/or publication of this article.

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