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Evaluation of Renal Function and Other Relevant Parameters in Living Kidney Donors after Nephrectomy

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Background: Kidney transplantation, especially from a living donor, is a preferred treatment for many with chronic kidney disease (CKD). Unilateral nephrectomy reduces total glomerular filtration rate (GFR), impacting kidney function, arterial hypertension, proteinuria, and other biochemical issues. Evaluation and follow-up of donors are crucial. *This study aimed to evaluate the renal function and other relevant parameters in living kidney donors after nephrectomy.*
Methods: This prospective, observational was conducted in the Department of Nephrology, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh from January 2017 to August 2018. A total of 25 adult patients who underwent donor nephrectomy were purposively enrolled as study subjects. Data were analyzed using SPSS version 23.0.
Results: Participants' serum creatinine levels significantly ($p<0.05$) rose at 1-, 3-, 6-, and 12-months post-surgery compared to baseline. Both 24-hour creatinine clearance and eGFR significantly ($p<0.05$) decreased at 1, 3, 6, and 12 months after surgery. GFR was notably ($p<0.05$)

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lower at 6- and 12-months post-surgery. Conversely, 24-hour urinary total protein (UTP) levels significantly ($p<0.05$) increased at 1, 3, 6, and 12 months after surgery. From baseline to 12 months' post-donation, serum intact parathyroid hormone and uric acid levels were notably ($p<0.05$) higher, while hemoglobin, serum calcium, serum phosphorus, and serum albumin levels were significantly ($p<0.05$) lower. Kidney size showed significant ($p<0.05$) increases at 1-, 3-, 6-, and 12-months post-surgery.

Conclusion: Living kidney donors may experience a mild decline in glomerular filtration rate (GFR) and biochemical changes following nephrectomy. However, short-term follow-up suggests that outcomes of kidney donation appear safe. Nevertheless, it's crucial to monitor living kidney donors for potential adverse outcomes of donation.

Keywords: Renal function; living kidney donors; nephrectomy; serum creatinine; hemoglobin; serum albumin.

1. INTRODUCTION

Kidney transplantation, especially from living donors, is the preferred treatment for most patients with chronic kidney diseases. This method has shown superior results, leading to its increasing popularity. Studies suggest that kidney donors have similar or even longer life expectancy compared to non-donors [1]. The first successful human kidney transplantation took place in 1954 between identical twins [2]. This procedure is the only curative treatment for terminal uremia caused by primary renal diseases, congenital urinary tract dysplasia, and systemic diseases affecting the kidneys such as Diabetes Mellitus, Systemic Lupus Erythematosus, and Amyloidosis, which can lead to end-stage renal disease. The primary criterion for living kidney donation is having a normal glomerular filtration rate. Ideally, kidney donors should not have arterial hypertension or proteinuria. Following nephrectomy, the remaining kidney undergoes functional adaptation, including increased renal filtration in each nephron due to elevated renal plasma flow, leading to increased intra-glomerular pressure [3]. This renal hyperfiltration results in a measurable increase in renal volume [4]. Initially, hyper-filtrating glomeruli exhibit progressive enlargement, followed by the development of morphological lesions, particularly in the glomerular basement membrane, leading to the onset of proteinuria [3,5]. "Post-operative mortality risk for living kidney donation is exceedingly low. In the 1980s, this risk decreased to 0.04%, and by the end of the 20th century, it was even lower (0.01–0.03%)". [6] "In healthy young donors (<60 years old), post-donation glomerular filtration rate typically reaches 65–70% of the pre-donation GFR, with an increase observed as early as 8 hours' post-donation (with a measured GFR at 66% of the pre-donation GFR)" [7]. "However, this renal adaptation capability diminishes by half post-donation, especially in older or obese patients" [8, 9]. Barri et al. [10] observed that "post-donation GFR, measured by a reference method (iothalamate clearance), could decrease below the threshold of 60 ml/min in 27% of the population, particularly in older patients". The decrease in GFR post-donation is not deemed deleterious by the authors, as it occurs in only 10% of patients aged <30 years but in 91% of those aged 60 to 69 years. A GFR of approximately 60 ml/min may be considered normal in elderly healthy individuals due to the physiological decline in GFR with age. In a follow-up of at least 10 years, Garg et al. [11] demonstrated that "40% of donors had an estimated GFR between 60 and 80 ml/min, 12% between 30 and 59 ml/min, and only 0.2% <30 ml/min". "The probability of developing CKD after a living donation is fortunately very low. Diabetes and congestive heart failure are among the most frequent causes of end-stage renal disease (ESRD) in donors, with the risk estimated at 180 cases/million/year. A Swedish study conducted between 1965 and 2005 reported that 6 out of 1112 donors progressed to ESRD (incidence rate of 0.5%)" [12]. "End-stage renal disease (ESRD) typically manifests between 14 and 27 years after donation, with proteinuria usually <1 g/24 hours in the majority of donors and severe nephrotic proteinuria being rare" [13]. Studies by Fehram-Ekholm (using dipstick for proteinuria screening) and Ibrahim (measuring albuminuria) reported "proteinuria prevalence rates of 9% and 12%, respectively. Donors often experience a significant increase in systolic and/or diastolic arterial pressure after kidney donation". Goldfarb et al. [14] re-evaluated "43% of patients from a population of 573 kidney donors with a mean follow-up of 25 years and found that at 64 years old, the prevalence of hypertension reached

48%". In 2006, Boudville et al. [15] described "an increase of 5 mmHg in blood pressure in the 5–10 years following kidney donation. Hyperuricemia has long been suggested to contribute to CKD, hypertension, diabetes, and cardiovascular disease". The objective of this study was to evaluate the renal function and other relevant parameters in living kidney donors after nephrectomy.

2. METHODOLOGY

This was a prospective, observational study that was conducted in the Department of Nephrology, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh from January 2017 to August 2018. As the study subjects, a total of 25 adult patients who had undergone donor nephrectomy were enrolled. A purposive sampling technique was employed for sample selection, The study assessed participants' GFR, proteinuria, hypertension, and other relevant parameters before and at 1 month, 3 months, 6 months, and 12 months after unilateral nephrectomy. Demographic and clinical information was recorded for all participants, and data analysis was conducted using SPSS version 23.0. A significance level of $p < 0.05$ was used for statistical analysis.

3. RESULTS

In this study, the majority of patients, 10 (40.0%), belonged to the age group of 31-40 years, while the lowest proportion, 2 (8.0%), were aged over 50 years. The mean age was 39.8 ± 8.6 years, ranging from 23 to 55 years. Males accounted for 11 (44.0%) of the patients, with females comprising 14 (56.0%), resulting in a male-to-female ratio of 0.79:1. Regarding education level, the majority of patients, 10 (40.0%), had completed HSC education. Among the participants, 21 (84.0%) were married, while 4 (16.0%) were unmarried. Nearly half of the patients, 48.0%, hailed from rural areas, with the remaining 52.0% coming from urban areas. There was no statistically significant difference ($p > 0.05$) observed in the mean systolic and diastolic blood pressure of our participants when comparing baseline values to those at 1, 3, 6, and 12 months, respectively. We found that the mean BMI did not show a statistically significant difference ($p>0.05$) when comparing baseline measurements with those at 1, 3, 6, and 12 months, respectively. In this present study, the mean serum creatinine showed a statistically significant difference ($p<0.05$) when comparing baseline measurements with those at 1, 3, 6, and 12 months, respectively. In analyzing the follow-up of 24-hour creatinine clearance and eGFR (CKD-EPI), we observed that the mean 24-hour creatinine clearance and eGFR (CKD-EPI) were significantly decreased ($p<0.05$) at 1 month, 3 months, 6 months, and 12 months of follow-up compared to baseline levels. The mean GGFR was significantly ($p<0.05$) decreased at 6 months and 12 months follow up than baseline. In our study, the mean GFR of the participants was

Table 1. Distribution of the study patients by socio demographic variable. (N=25)

Variable	n	%
Age (Year)		
≤30	4	16
31-40	10	40
41-50	9	36
>50	2	8
Mean ±SD	39.8±8.6	
Sex		
Male	11	44
Female	14	56
Educational status		
Below SSC	7	28
SSC	7	28
HSC	10	40
Graduate	1	4
Marital status		
Married	21	84
Unmarried	4	16
Residence		
Rural	12	48
Urban	13	52

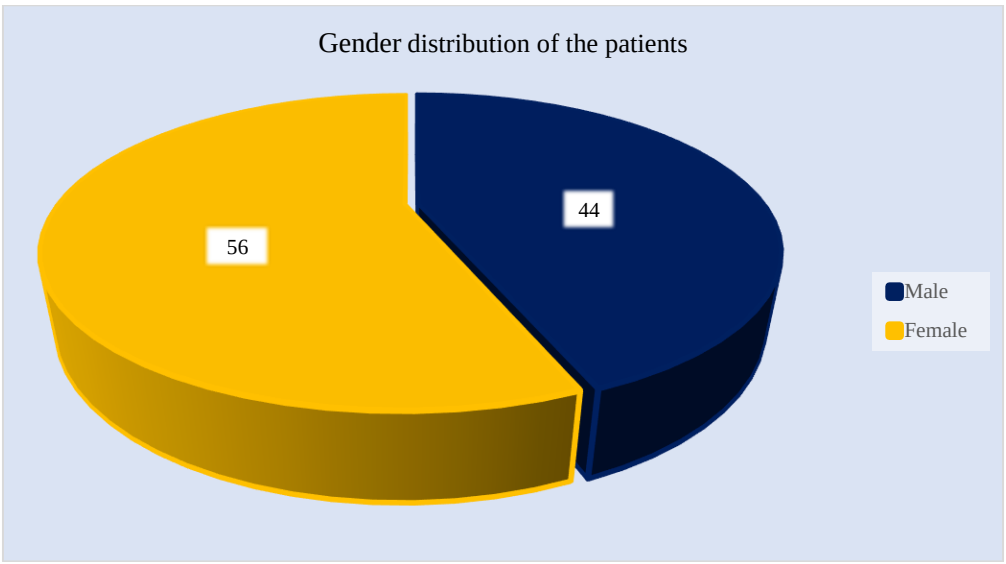

Fig. 1. Pie chart showed gender distribution (N=25)

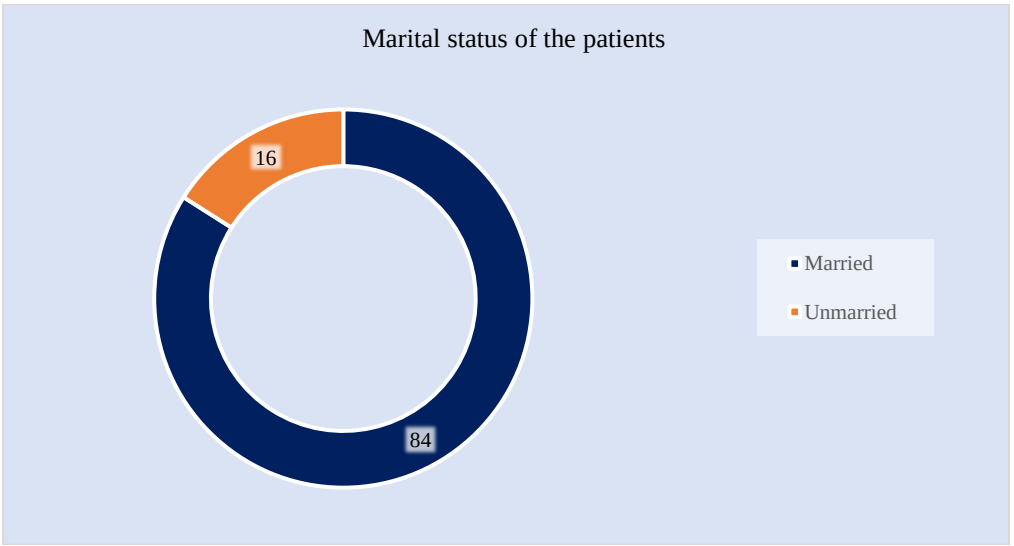

Fig. 2. Ring chart showed marital status wise patients distribution (N=25)

Table 2. Follow-up of blood pressure of study population. (N=25)

Blood pressure	Baseline	At 1 month	At 3 months	At 6 months	At 12 months	P-value
Systolic BP (mmHg)	110.0±9.0	110.0±8.0	112.0±7.0	113.0±8.0	112.0 ±7.0	0.131^{ns}
Diastolic BP (mmHg)	71.0±8.0	71.0±8.0	72.0±8.0	72.0±8.0	73.0±8.0	0.257^{ns}

Table 3. Follow-up of BMI (N=25)

BMI status	Baseline	At 1 month	At 3 months	At 6 months	At 12 months	P value
BMI (kg/m^2)	23.1±3.4	22.5±1.2	22.8±1.3	23.2±1.3	23.7±1.7	0.084^{ns}

significantly ($p<0.05$) decreased at 6 months and 12 months of follow-up compared to baseline. The mean serum uric acid and intact parathyroid hormone (IPTH) levels were significantly

(p<0.05) increased at 1, 3, 6, and 12 months of follow-up compared to baseline. However, the mean serum calcium and phosphorus levels were significantly (p<0.05) decreased at 1, 3, 6, and 12 months of follow-up compared to baseline. The mean hemoglobin and serum albumin levels were significantly (p<0.05) decreased at 1, 3, 6, and 12-month follow-up compared to baseline. However, the mean 24-hour urine total protein (UTP) was significantly (p<0.05) increased at 1, 3, 6, and 12-month follow-up compared to baseline. Mean fasting blood sugar (FBS) did not show statistical significance (p>0.05) when compared to baseline at different follow-up intervals. In this study, the mean kidney size was 9.6±0.6 cm at baseline, 9.9±0.6 cm at 1 month, 10.2±0.6 cm at 3 months, 10.4±0.6 cm at 6 months, and 10.4±0.6 cm at 12 months. The mean kidney size was significantly (p<0.05) increased at 1 month, 3 months, 6 months, and 12 months' follow-up compared to baseline.

Table 4. Follow-up of serum creatinine (N=25)

Variable	Baseline	At 1 month	At 3 months	At 6 months	At 12 months	P value
S. creatinine (mg/dl)	0.93±0.16	1.32±0.18	1.26±0.11	1.18±0.12	1.14±0.14	0.001s

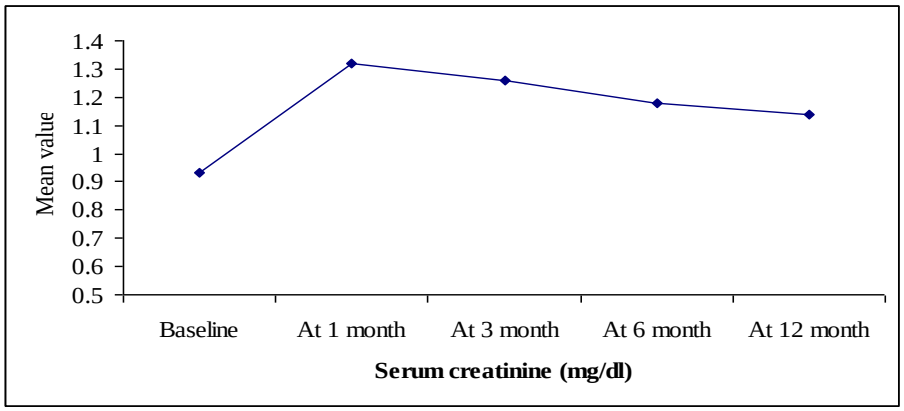

Fig. 3. Line chart showed serum creatinine in different follow-ups (N=25)

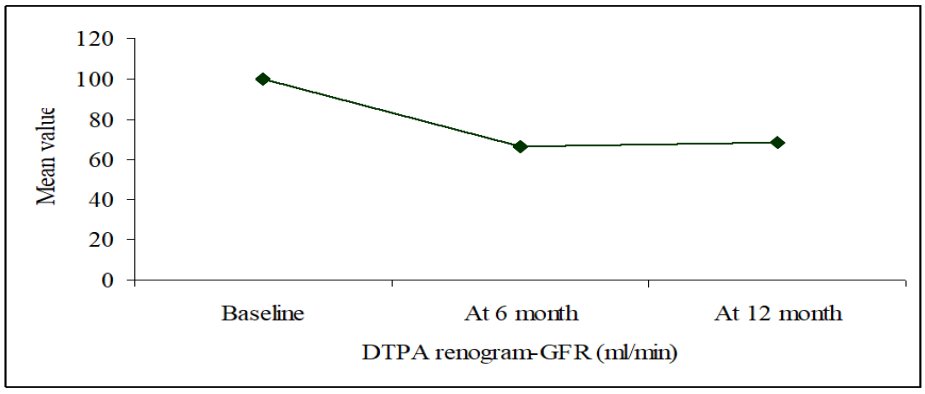

Fig. 4. Line chart showed GGFR in different follow-ups. (N=25)

Table 5. Follow-up of 24 hours' creatinine clearance and eGFR (CKD-EPI) (N=25)

Parameters	Baseline	At 1 month	At 3 months	At 6 months	At 12 months	P-value
24 hours creatinine clearance (ml/min)	96.0±13.1	64.2±9.6	65.1±10.5	66.8±11.3	68.7±10.6	0.001[s]
eGFR (CKD-EPI) (mL/min/1.73m²)	89.0±15.4	58.8±11.0	62.1±12.0	66.7±12.8	69.4±13.1	0.001[s]

Table 6. Follow-up of GGFR (DTPA renogram) (N=25)

Variable	Baseline	At 6 months	At 12 months	P value
GGFR (ml/min)	99.7±19.4	66.2±13.1	68.6±12.3	0.001s

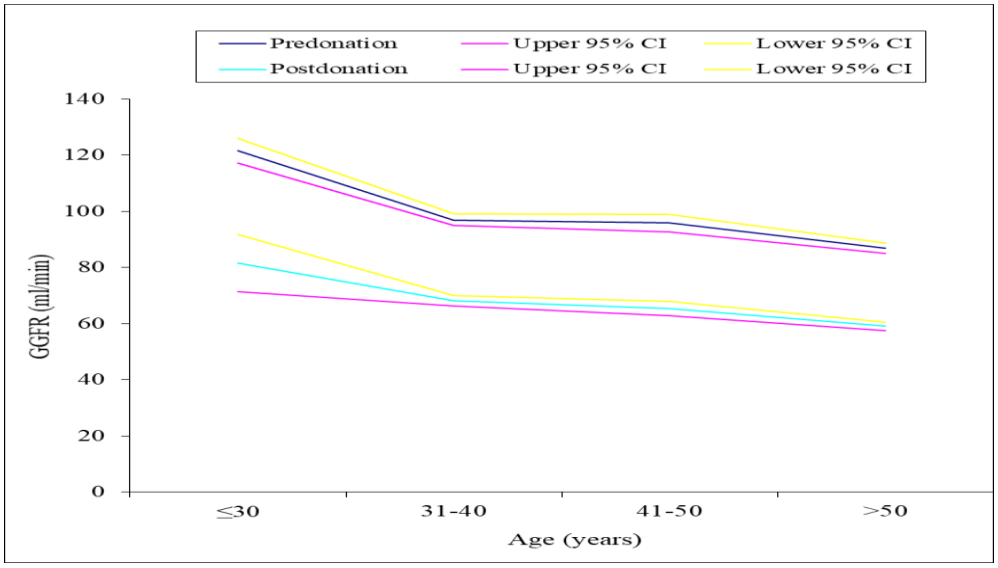

Fig. 5. Line chart showed pre-donation and post-nephrectomy GGFR (DTPA renogram) and relation to age in healthy donors

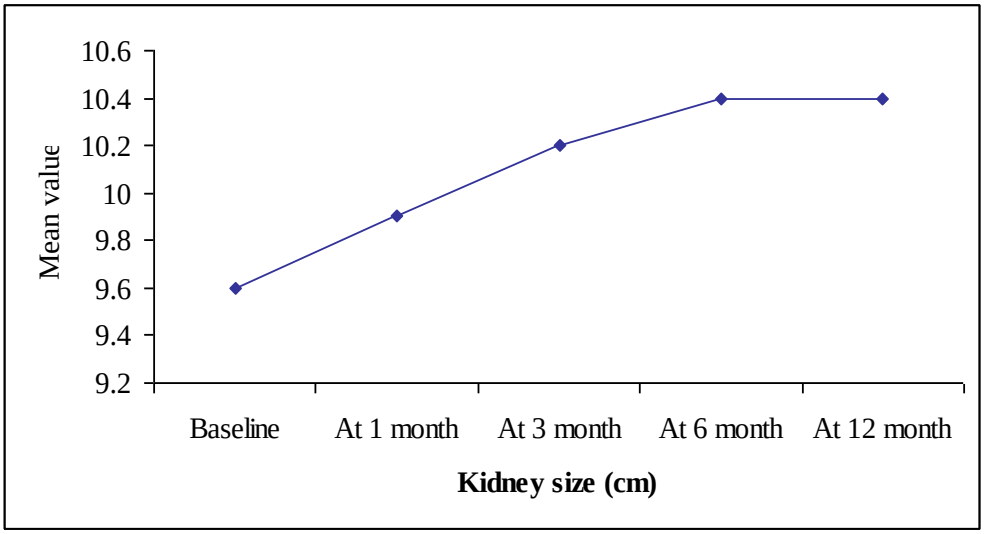

Fig. 6. Line chart showed kidney size in different follow-ups (N=25)

Table 7. Follow-up of serum uric acid, calcium, phosphorus, and IPTH (N=25)

Parameters	Baseline	At 1 month	At 3 months	At 6 months	At 12 months	P-value
Serum uric acid (mmol/L)	2.8±0.5	3.1±0.7	3.1±0.6	3.3±0.6	3.4±0.6	0.001[s]
Serum calcium (mg/dl)	9.3±0.7	8.9±0.7	8.7±0.6	8.6±0.7	8.5±0.7	0.001[s]
Serum phosphorus (mg/dl)	3.2±0.6	3.1±0.6	3.1±0.6	2.9±0.6	2.9±0.5	0.001[s]
IPTH (PGM/ml)	29.7±8.7	34.48.3	38.5±8.3	43.1±9.0	46.6±9.4	0.001[s]

Table 8. Follow-up of hemoglobin, 24 hours UTP, serum albumin, and FBS (N=25)

Parameters	Baseline	At 1 month	At 3 months	At 6 months	At 12 months	P-value
Hemoglobin (gm/dl)	12.9±1.5	12.0±1.4	12.0±1.4	11.9±1.2	11.8±1.4	0.001[s]
24 hours UTP (gm/day)	0.11±0.04	0.22±0.08	0.26±0.06	0.28±0.06	0.29±0.05	0.001[s]
S. albumin (gm/L)	43.5±2.6	41.2±2.1	40.2±2.3	38.8±2.0	37.4±2.0	0.001[s]
FBS (mmol/L)	4.9±0.7	4.9±0.7	4.9±0.6	4.8±0.5	4.7±0.4	0.067[ns]

Table 9. Follow-up of kidney size (N=25)

Size	Baseline	At 1 month	At 3 months	At 6 months	At 12 months	P value
Kidney size (cm)	9.6±0.6	9.9±0.6	10.2±0.6	10.4±0.6	10.4±0.6	0.001[s]

4. DISCUSSION

In this study, the majority of patients (40.0%) belonged to the age group of 31-40 years, while the lowest proportion (8.0%) were aged over 50 years. The mean age of the participants was 39.8 ± 8.6 years. Kasiske et al. [16] reported a similar trend, with the majority (40.9%) of patients belonging to the age group of 35-49 years, while the lowest proportion (2.5%) were aged ≥65 years. There was no statistically significant difference ($p>0.05$) observed in the mean systolic and diastolic blood pressure of our participants when comparing baseline values to those at 1, 3, 6, and 12 months, respectively. A similar study by Kasiske et al. [17] found that mean systolic and diastolic blood pressure were statistically significant ($p<0.05$) when comparing donors versus donor visits group with a follow-up of three years. In this study, it was observed that BMI was not statistically significant ($p>0.05$) when comparing baseline vs. at 1, 3, 6, & 12 months, respectively. Similarly, Nagib et al. [18] found in their study that the mean BMI (kg/m2) increased significantly after donation. In this present study, it was observed that serum creatinine levels were 0.93±0.16 mg/dl at baseline, 1.32±0.18 mg/dl at 1 month, 1.26±0.11 mg/dl at 3 months, 1.18±0.12 mg/dl at 6 months, and 1.14±0.14 mg/dl at 12 months. Serum creatinine was significantly ($p<0.05$) higher at 1, 3, 6, and 12-month follow-up than at baseline. A similar study conducted by Kasiske et al. [17] found that the mean serum creatinine was 0.80±0.15 mg/dl at the baseline visit, 1.16±0.22 mg/dl at the 6-month visit, and 1.15±0.22 mg/dl at the 12th-month visit, showing a significant ($p<0.05$) increase in follow-up visits compared to the baseline visit. In this study, it was observed that 24-hour creatinine clearance and eGFR (CKD-EPI) were significantly ($p<0.05$) decreased at 1 month, 3 months, 6 months, and 12 months of follow-up compared to baseline. This finding is consistent with the study by Barri et al. [10], where they showed that mean 24-hour creatinine clearance and eGFR were significantly ($p < 0.05$) decreased post-donation compared to pre-donation levels. Additionally, Ibrahim et al. [19] documented in their study that a longer time since donation and a higher estimated GFR at the time of donation were associated with a greater compensatory increase in the estimated GFR in the remaining kidney. In this current study, the GFR by radioisotope (DTPA renogram) was 99.7±19.4 ml/min at baseline, decreasing to 66.2±13.1 ml/min at 6 months and 68.6±12.3 ml/min at 12 months. This decrease was statistically significant ($p<0.05$) at 6 and 12 months compared to baseline. The nephrectomy was followed by a compensatory increase in GFR in the remaining kidney to about 66% of pre-nephrectomy values in this study. Similarly, Mehta et al. [20] observed a significant reduction in post-donation GFR from 94.50±18.12 ml/min pre-donation to 60.48±14.32 ml/min post-donation ($p<0.0001$). They also noted a significant increase in remnant kidney GFR from 48.83±7.79 ml/min pre-donation to 60.48±14.32 ml/min post-donation ($p<0.0001$). In this study, serum uric acid levels were significantly ($p<0.05$) increased at 1, 3, 6, and 12 months of follow-up compared to baseline. This finding is consistent with the results of Kasiske et al. [16], who reported a significant increase in mean serum uric acid from 4.6±1.1 mg/dl at baseline to 5.3±1.1 mg/dl at the 6th-month visit ($p<0.05$). Furthermore, Hida et al. [21] observed a 24.3% increase in uric acid levels from a mean of 4.78±1.26 mg/dl before donation to 5.88 ± 1.40 mg/dl between 6 months and 5 years after donation for 34 donors. In our study, serum intact parathyroid hormone (IPTH) levels were significantly ($p<0.05$) increased at 1, 3, 6, and 12 months of follow-up compared to baseline.

Conversely, mean calcium and phosphorus levels were significantly ($p<0.05$) decreased at 1, 3, 6, and 12 months of follow-up compared to baseline. However, Kasiske et al. [16] reported non-significant changes in mean calcium levels between baseline (9.26±0.38 mg/dl) and the 6th-month visit (9.24±0.42 mg/dl) ($p>0.05$). They also observed a significant decrease in mean phosphorus levels from baseline (3.52±0.50 mg/dl) to the 6th-month visit (3.30±0.48 mg/dl) ($p<0.05$). In this setting, serum albumin levels were significantly ($p<0.05$) decreased at 1, 3, 6, and 12 months of follow-up compared to baseline. Conversely, mean 24-hour urinary total protein (UTP) was significantly ($p<0.05$) increased at 1, 3, 6, and 12 months of follow-up compared to baseline. However, fasting blood sugar (FBS) levels did not show statistical significance ($p>0.05$) when compared between baseline and different follow-up time points. This is consistent with findings by Kasiske et al. [16], where they observed a significant decrease in mean serum albumin levels from baseline (4.18±0.29 mg/dl) to the 6th-month visit (4.07±0.33 mg/dl) ($p<0.05$). Additionally, Nagib et al. [18] documented that blood sugar and serum albumin remained within normal levels throughout the observational period, while urinary protein excretion increased in the first three months after donation before stabilizing over the remaining period of the study. In this present study, the mean kidney size of the participants was significantly ($p<0.05$) increased at 1 month, 3 months, 6 months, and 12 months of follow-up compared to baseline. This finding indicates a compensatory hypertrophy of the remaining kidney, evidenced by an increase in kidney size over time during the observational period. Mehta et al. [20] demonstrated a significant increase in remnant kidney size from 35.12±6.80 cm2 to 42.32±8.59 cm2 ($p<0.0001$) in their study. Additionally, Bohlouli et al. [22] reported that remnant kidney length, anterior-posterior diameter, and cortical thickness were significantly increased during post-nephrectomy follow-up.

5. CONCLUSION

There appears to be a mild decline in glomerular filtration rate (GFR) along with biochemical alterations in living kidney donors following nephrectomy. However, the outcomes of kidney donation seem to be safe in the short-term follow-up. Living kidney donors must be closely monitored for any adverse outcomes associated with the donation process.

6. LIMITATION OF THE STUDY

There are several limitations to this study. Firstly, the sample size was small, which may affect the generalizability of the findings. Secondly, the study was conducted over a limited time, potentially limiting its representation of the entire population. Additionally, the lack of consistency in the observer during the measurement of kidney size by ultrasonography for all study participants may introduce variability in the results.

CONSENT

Written consent was obtained from all participants before data collection. The study included patients aged 18 to 60 of both sexes who underwent donor nephrectomy and consented to participate. Exclusion criteria comprised any early postoperative complications that could adversely affect renal function or cause wound complications

ETHICAL APPROVAL

Ethical approval was obtained from the hospital's ethics committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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