TO INVESTIGATE THE CHANGES IN RENAL VOLUME AND FUNCTION THAT OCCUR AFTER UNILATERAL NEPHRECTOMY

[1]Dr. Tanmay Mehta, [2]Dr. Aniket Survase, [3]Dr. Pratik Ajagekar

[1,2,3]Assistant Professor, Department of General Surgery, Krishna VishwaVidhyapeeth, Karad, Maharashtra, India

Corresponding author: Dr. Tanmay Mehta, Assistant Professor, Department of General Surgery, Krishna VishwaVidhyapeeth, Karad, Maharashtra, India
Email: dr.tanmaymehta@gmail.com

ABSTRACT

Aim: The aim of this research is to investigate the changes in renal volume and function that occur after unilateral nephrectomy.

Material and Methods: This is a prospective study, observational study, and cross-sectional study of all of the patients who receive nephrectomy at tertiary care hospitals for kidney transplantation, cancer, and other renal illnesses. Throughout the course of the research, a total of one hundred individuals who had a nephrectomy performed either openly or laparoscopically were evaluated. Each patient's complete medical history has been meticulously documented.

Results: Of them, 23 were performed as part of a kidney donation, 25 were performed due to renal cancer, and 52 were performed due to disease. We had three patients with tuberculosis, seventeen with pelviureteric junction obstruction, seven with xanthogranulomatous pyelonephritis, six with emphysematous pyelonephritis, seventeen with pyonephrosis, one with angiomyolipoma, and one with renal artery thrombosis among these 52 diseased nephrectomies. Nephrectomies including the donation of kidney tissue were performed on 23 patients, while radical nephrectomies were carried out on 25 individuals. The remaining 52 patients all had either a simple or subcapsular nephrectomy performed on them. Because of this, the majority of patients in our research were from a nephrectomy group for illness.

Conclusion: The differences in the functional and volumetric outcomes after unilateral nephrectomy may be organised in descending order as follows: donor nephrectomy group, radical nephrectomy group, and finally diseased nephrectomy group.

Keywords: Renal volume, unilateral nephrectomy**,** donor, radical

Introduction

Nephrectomy is a surgical procedure that involves the removal of a kidney. This procedure is used to treat a variety of kidney illnesses, including cancer of the kidney. In the context of a kidney transplant, this surgery is also carried out in order to harvest a normally functioning kidney from either a live or a dead donor [1]. In modern times, malignancy, trauma, and

kidney transplantation are the most prevalent triggers for nephrectomy procedures. Patients who have reached the terminal stage of renal illness are often candidates for kidney transplantation from a living donor. The unintentional discovery of renal masses by imaging has led to an increase in the number of patients who have nephrectomy for treatment of renal cancer. In addition, nephrectomy may be necessary in cases when the kidney has been irreparably damaged as a result of a chronic infection, blockage, calculus disease, pyelonephritis, or dysplasia of the kidneys [2].

When a kidney that is otherwise healthy is surgically removed, the other kidney undergoes significant transformations. Very immediately after a unilateral nephrectomy, there is an increase in both the size and functioning of the kidney, most notably the glomerular filtration rate (GFR) and the renal plasma flow (RPF) [3].
In the 8 to 12 weeks after a nephrectomy, the remaining kidney goes through a process of compensatory adaptation, which results in an increase in its total glomerular filtration rate (GFR) of around 70 percent of its value before to surgery [4]. The glomerular filtration rate (GFR) test is widely recognised as the most effective method for evaluating renal function as a whole. It was discovered that even while the kidney that was left behind continued to function normally, it nonetheless underwent self-mutilation in the form of glomerulosclerosis and interstitial damage [5]. There were a number of autopsy investigations that pointed to a high correlation between the volume of the kidneys and the number of nephrons that were active [6]. In the context of donor nephrectomy, kidney volume directly corresponds with renal function in living donors and influences the post-transplantation outcomes of grafts; CT measured parenchyma strongly correlates with differential renal function on a nuclear renal scan for normal or chronically obstructed kidneys [7]. Moreover, a strong association was found between preoperative and postoperative kidney volume and each patient's GFR after unilateral nephrectomy [8]. In addition, research has shown that the preoperative kidney volume of donor patients may be used as a predictor of delayed renal function when it is evaluated 6 months following surgery [9].

It is essential to do an accurate assessment of the function and volume of each kidney both before to and during surgery if one wants to determine the parameters that influence the likelihood of renal failure following unilateral nephrectomy. In earlier research, the GFR of each kidney in binephric patients was stated as half of the comparable value for two kidneys[10]. This was done to compare the GFR of each kidney to the value for two kidneys. Nevertheless, since creatinine clearance affects the overall GFR rather than the individual kidney function, this technique does not adequately represent the individual function of each of the kidneys. The Tc-99m DTPA scan has been verified and recognised as a technique for assessing the GFR as a measure of both the overall renal function as well as the specific function of each of the kidneys [11]. This means that this scan can be relied on to provide accurate results when used for this purpose. So, in order to get a better understanding of the relationship between these two elements, we want to conduct an investigation of the changes that occur in the postoperative glomerular filtration rate (GFR) as well as the kidney volume after nephrectomy.

Material and Methods

This is a prospective study, observational study, and cross-sectional study of all of the patients who receive nephrectomy at tertiary care hospitals for kidney transplantation, cancer, and other renal illnesses. Throughout the course of the research, a total of one hundred individuals who had a nephrectomy performed either openly or laparoscopically were evaluated. Each patient's complete medical history has been meticulously documented.

Inclusion Criteria

- A radical nephrectomy, either open or laparoscopic, was performed on all patients aged 20–75 years old who were diagnosed with RCC and urothelial malignancies.
- Over the course of the trial, operations were performed on all live kidney donors between the ages of 20 -60.
- Nephrectomy, either simple or subcapsular, was performed on every patient between the ages of 20 -75 due to a wide variety of benign and infectious causes.

Exclusion Criteria

Patients who had an abnormal radiological kidney on the contralateral side, a solitary kidney, or synchronous RCC, patients who had metastatic or locally advanced cancer at RN (pT4/N1–2), patients who had previous surgery for RCC, and patients who had pre-existing severe renal insufficiency (defined as an eGFR of 30 mL/min/1.73 m2) were excluded from the study. Donors with age more than 50 years, a glomerular filtration rate of less than 80 ml/min, hypertension, and diabetes.

Before and one month after surgery, non-contrast computed tomography (NCCT) and dual-energy positron emission tomography (DTPA) scans were performed on all of the patients. The renal parenchymal volume can be calculated by ellipsoid formula as volume = length (average of sagittal and coronal lengths) × width × depth × $\pi/6$. Throughout the course of the DTPA scan, the estimated GFR is computed. Comparisons of both parameters will be made with the help of the suitable software. The patients who were receiving RN for solitary renal masses (RCC group), donor nephrectomy for renal transplantation, and the proper form of nephrectomy for different renal illnesses were matched for age and gender to the group that was the most suited for them.

Tc-99m DTPA scintigraphy was used both before to and during nephrectomy in order to ascertain the GFR of each individual kidney. For calculating renal volume, a non-contrast CT scan using a 128 slice, 72 kW CT scan machine with a 5 mm cut section is used both before and after a nephrectomy.

A gamma camera based on the Gates approach was used in order to get quantitative images of Tc-99m DTPA uptake in the kidneys. After administering 75–150 MBq (5 mCi) of Tc-99m DTPA through intravenous injection to the patient, the Gates analysis was carried out between two and three minutes after the tracer was administered. It was determined that each kidney and perirenal semilunar background area had a region of interest associated with it. The Symbia E twin head gamma camera was used in order to get pictures of the perfusion

and dynamic processes. All of the GFR values were adjusted based on the depth adjustment, as well as the normalised correction.

The linear renal parameters (length, lateral diameter, and anterior-posterior diameter) were measured in order to calculate the volume of the kidney. In order to determine the length of the kidneys based on axial slices, the slice thickness was multiplied by the number of slices that were taken between the superior and inferior ends of the kidneys. While breadth and thickness were being measured, the cross-sectional area represented by the slice was the biggest. Both the lateral diameter and the antero posterior diameter were measured in a direction that was perpendicular to the lateral diameter. The lateral diameter was determined by measuring the distance from the lateral limit of the kidney to the renal sinus. The ellipsoid formula was used to get an estimate of the renal volume from the linear dimensions. Before and after the nephrectomy, the exact same surgery was carried out. The ellipsoid formula to estimate renal volume = length ×lateral diameter ×anterior- posterior diameter ×π/6.

Statistical Analysis

Excel 2010 was used to do analyses on each and every piece of data that was obtained. The SPSS programme, version 25.0, was used to do the analysis on the statistical data. A paired t-test was used to make the comparison between the pre- and post-operative values of GFR and renal volume. A simple chi-square test was used in order to investigate categorical variables. A P value of less than 0.05 was used to indicate statistical significance.

Results

We are finding that there is a little greater proportion of females than males in the population that we are researching. In both the donor nephrectomy group and the diseased nephrectomy group, the presence of a female preponderance may be shown to a significant degree. Patients in the donor nephrectomy group have a mean age of 46.15 years, whereas those in the radical nephrectomy group have a mean age of 51.69 years and those in the diseased nephrectomy group have a mean age of 43.19 years. In both the group that had donor nephrectomy and the group that underwent diseased nephrectomy, the majority of the patients were between the ages of 50 – 65 years. Nevertheless, in the group of patients who had radical nephrectomy, individuals with ages ranging from 50 to 65 years and patients older than 65 years made up a nearly similar percentage of the total. In the donor nephrectomy group, there was not a single patient who fell into the age range of between 35 -65 years old. Just two patients in the diseased nephrectomy group were less than 35 years old at the time of surgery. Throughout the course of the research, there was not a single patient younger than 35 years old who was diagnosed with RCC.

Table 1: Distribution of Age group

Gender	Donor nephrectomy	Radical Nephrectomy	Diseased Nephrectomy	Total	Prcentage
Male	**9**	**20**	**27**	**56**	**56**
Female	**14**	**5**	**25**	**44**	**44**

Age					
below 35	0	0	2	2	2
35-50	7	6	28	41	41
50-65	16	12	21	49	49
Above 65	0	7	1	8	8
Mean age	46.15±5.25	51.69±7.85	43.19±8.25		

Table 2: Surgery Wise Distribution

Operative Side	**Donor Nephrectomy**	**Radical Nephrectomy**	**Diseased Nephrectomy**	**Total**	**Percentage**
Left	13	10	29	52	52
Right	10	15	23	48	48
Total	23	25	52	100	100

Nephrectomies including the donation of kidney tissue were performed on 23 patients, while radical nephrectomies were carried out on 25 individuals. The remaining 52 patients all had either a simple or subcapsular nephrectomy performed on them. Because of this, the majority of patients in our research were from a nephrectomy group for illness.

Table 3: Etiological Distribution

Surgery	**Etiology**		**No. Of Patients**
Donor Nephrectomy			23
Radical Nephrectomy	Renal Malignancy	25	25
Diseased Nephrectomy	TB	3	52
	PUJO	17	
	XGPN	7	
	EPN	6	
	Pyonephrosis	17	
	Angiomyolipoma	1	
	Renal Artery Thrombosis	1	

As can be seen in the table that follows, we conducted our research on a total of one hundred individuals who had had nephrectomy for a variety of reasons. Of them, 23 were performed as part of a kidney donation, 25 were performed due to renal cancer, and 52 were performed due to disease. We had three patients with tuberculosis, seventeen with pelviureteric junction obstruction, seven with xanthogranulomatous pyelonephritis, six with emphysematous pyelonephritis, seventeen with pyonephrosis, one with angiomyolipoma, and one with renal artery thrombosis among these 52 diseased nephrectomies.

Table 4: Mean GFR Before and After Nephrectomy

Surgery	**Pre-op GFR (ml/min)**	**Post-op GFR (ml/min)**	**Mean Difference**	**p-value**
Donor	55.15±4.22	80.41±2.14	25.26±2.08	<0.05

Nephrectomy				
Radical Nephrectomy	47.21±5.21	63.33±4.19	16.12±1.02	<0.05
Diseased Nephrectomy	50.17±4.32	65.74±5.63	15.57±1.31	<0.05

Improvements in GFR and kidney volume were seen post-nephrectomy in various degrees across all groups, regardless of the kind of nephrectomy that was performed. Donor nephrectomy group is displaying better postoperative GFR with kidney volume and greater improvement as compared to their preoperative values, when compared to the other two groups. In a similar manner, the table displays the proportion of each nephrectomy group's GFR that increased after surgery. The table presents the mean difference for each nephrectomy group, and the p-value for this difference is less than 0.05 for each of the groups.

Table 5: Mean RPV Before and After Nephrectomy

Surgery	**Pre-op RPV** (cm3)	**Post-op RPV** (cm3)	**Mean Difference** (cm3)	**p-value**
Donor Nephrectomy	155.88±6.58	176.36±5.25	20.12±1.33	<0.05
Radical Nephrectomy	155.95±5.89	175.44±4.26	19.49±1.63	<0.05
Diseased Nephrectomy	149.25±6.37	166.38±4.66	17.13±1.71	<0.05

In a similar vein, when it comes to RPV improvement, the diseased nephrectomy group exhibits the smallest mean difference, while the donor nephrectomy group shows the biggest mean difference. The table shows the percentage increase that may be attributed to each kind of nephrectomy. There is a statistically significant difference between the means of all nephrectomies, and the p-value for this difference is less than 0.05.

Discussion

This current research is a prospective investigation that was carried out with the purpose of comparing the renal function and RPV result after nephrectomy for various causes. We examined the result by comparing the GFR of the remaining kidney pre- and post-operatively with the use of a DTPA renogram, while the changes in RPV were measured by the NCCT KUB.

Patients in the study group have an average age of 46.15 years, with a standard deviation of 5.25 years; patients in the donor nephrectomy group have an average age of 51.69 years, with a standard deviation of 7.85 years; patients in the radical nephrectomy group have an average age of 43.19 years, with a standard deviation of 8.25 years. In both the group that had donor nephrectomy and the group that underwent diseased nephrectomy, the majority of the patients were between the ages of 50-65. According to the Indian transplant registry, the average age of a donor in the year 2014 was between the ages of 35 - 49. In an earlier research conducted

in 2013, Miki N. and colleagues found that the average age of donors was 59.1 years old. The average age of the donors in our research was 46.15 years, with a standard deviation of 5.25 years; this is virtually identical to the average age listed in the Indian transplant registry[12]. In the research conducted by Suraj Godara et al., the average age of the sick group was found to be 48.7±5.5 years, but in the study conducted by Funahashi et al., the average age of the study population was found to be 62.3±13.3 years [13,14]. In one research, Emamian SA et al. found that the mean RPV in the left kidney was 146 cm3, whereas the mean RPV in the right kidney was 134 cm3 in 665 adult volunteers [15]. According to the findings of our research, the mean RPV for the left side is 153.11 cm3 with a standard deviation of 7.69 cm3, while the mean RPV for the right side is 150.18 cm3 with a standard deviation of 7.96 cm3. Because of the relatively small sample size, the difference in volume between the left and right sides of the kidney may not be all that significant. Our sample size for the left side of the kidney was 52, while our sample size for the right side was 48. In the same way as the previous research, no data were discovered that showed a variation in GFR depending on which side of the kidney was examined.

In the current research, the average percentage increase in the GFR of the contralateral kidney in the donor nephrectomy group was 46%. This is contrasted to the radical nephrectomy group (36%), which had the lowest increase, and the disease nephrectomy group (33%), which had the highest increase. Z. Chen et al.[16], in 2012, in his research demonstrated a 22% rise in GFR post 1-month nephrectomy and 23.5% increase in GFR post 12 months nephrectomy in the donor Nephrectomy group, and both values are not statistically different at 1 and 12 months after donor Nephrectomy. It was also shown by Kim et al. in 2010 that the mean decrease in GFR was substantially higher in the donor nephrectomy group compared to the disease nephrectomy group (11.1±1 8.5ml/min vs. 5.6 ±1.2ml/min, $p< 0.05$). [17].

The pre-operative GFR was found to be lower in the group of the study that was advanced in age. This change in GFR with advanced age in the current research cohort was comparable to the change that occurs in the general population. GFR is known to decline with age in the general population and this decline often starts around the age of 40. As a person reaches the age of 50, the rate of GFR reduction accelerates. The drop in GFR is about one millilitre per minute per year between the ages of 35 - 55, and it increases to approximately one and a half millilitres per minute per year beyond the age of 55.

When looking at the RPV, the group that donated the most had the biggest rise in mean value (14%), in comparison to the radical group (13%) and the ill group (12%). Because he found unaffected kidneys to be 36% larger than the corresponding normal kidney in binephric individuals one month before nephrectomy, Prassonpoulos et al. had deduced that the compensatory reaction in the remaining kidney occurs before surgery in patients with renal cell cancer. [18]

Conclusion

After surgery, the DTPA-GFR and RPV of the contralateral kidney progressively rose in every group that had a nephrectomized kidney removed. The differences in the functional and volumetric outcomes after unilateral nephrectomy may be organised in descending order as follows: donor nephrectomy group, radical nephrectomy group, and finally diseased

nephrectomy group. The compensatory shift in GFR will aid in forecasting the variance in GFR that would occur following nephrectomy, and this is particularly true for individuals who are older. Alterations in the RPV of the kidney on the opposite side of the body aid to predict surgical CKD when combined with GFR data.

References

1. Mahesh Borikar, Bala Murali Krishna Patibandla, Ch Vishwajith Reddy, Mallipeddi Partha Sri, Arvind Kumar Prabhat, & Subbarao Chodisetti. Study of Renal Volume and Functional Changes in Unilateral Nephrectomy –Our Institutional Experience. *International Journal of Health and Clinical Research*.2022; *5*(2), 183–186.
2. Matsushita K, Kwak L, Sang Y, Ballew Shoshana H, Skali H, Shah Amil M, Coresh J, Solomon S. Kidney disease measures and left ventricular structure and function: the atherosclerosis risk in communities study.**J Am Heart Assoc**. 2017; 6:e006259.
3. Mangion K, McDowell K, Mark PB, Rutherford E. Characterizing cardiac involvement in chronic kidney disease using CMR-a systematic review.**Curr Cardiovasc Imaging Rep**. 2018; 11:2.
4. Bieniasz M, Domagala P, Kwiatkowski A, et al. The assessment of residual kidney function after living donor nephrectomy. Transplant Proc. 2009;41(1):91-2.
5. Poggio ED, Hila S, Stephany B et al. Donor kidney volume and outcomes following live donor kidney transplantation. Am J Transplant 2006; 6: 616– 24.
6. Hugen CM, Polcari AJ, Farooq AV, Fitzgerald MP, Holt DR, Milner JE. Size does matter: donor renal volume predicts recipient function following live donor renal transplantation. J Urol 2011; 185: 605– 9.
7. Morrisroe SN, Su RR, Bae KT *et al*. Di#erential renal function estimation using computerized tomography based renal parenchymal volume measurement. J Urol 2010; 183: 2289– 93.
8. Funahashi Y, Hattori R, Yamamoto T, Kamihira O, Sassa N, Gotoh M. Relationship between renal parenchymal volume and single kidney glomerular "Filtration rate before and after unilateral nephrectomy. Urology 2011; 77: 1404– 8
9. Jeon HG, Lee SR, Joo DJ *et al*. Predictors of kidney volume change and delayed kidney function recovery after donor nephrectomy. J Urol 2010; 184: 1057– 63
10. Miki N. Hew, Dedan Opondo, Ernesto R. Cordeiro, Karlijn A.M.I. van Donselaar. The 1-year decline in estimated glomerular filtration rate (eGFR) after radical nephrectomy in patients with renal masses and matched living kidney donors is the same ; BJU Int 2014; 113: E49–E55.
11. Chen Z, Fang J, Li G, Et Al. Qi Compensatory Changes In The Retained Kidney After Nephrectomy In A Living Related Donor. Transplantation Proceedings 2012;44: 2901–2905.
12. Kim, Hye & Chae, Sun-Young & Baek, Sora & Moon, Dae. Factors Affecting Changes in the Glomerular Filtration Rate after Unilateral Nephrectomy in Living Kidney Donors and Patients with Renal Disease. Nuclear Medicine and Molecular Imaging. 2010;44:69-74.
13. Yoshinori Shirasaki, Tomoyasu Tsushima, Takashi Saika, Et Al. Kidney Function After Nephrectomy For Renal Cell Carcinoma. Journal Of Urology 2004;64(1):43–47.

14. Shin HS, Chung BH, Lee SE, Kim WJ, Ha HI, Yang CW: Measurement Of Kidney Volume With Multidetector Computed Tomography Scanning In Young Korean. Yonsei Med J. 2009; 50:262-5
15. Roseman DA, Hwang SJ, Oyama,Manabe N, Chuang ML, O'Donnell CJ, Manning W J, Fox CS: Clinical Associations Of Total Kidney Volume: The Framingham Heart Study. Nephrol Dial Transplant 2017;32: 1344–1350.
16. Wang X, Vrtiska TJ, Avula RT, Walters LR, Chakkera HA, Kremers WK, Lerman LO, Rule AD : Age, Kidney Function, And Risk Factors Associate Differently With Cortical And Medullary Volumes Of The Kidney. Kidney Int 2014;85: 677– 685.
17. Musab S. Hommos, Richard J. Glassock And Andrew D. Rule : Structural And Functional Changes In Human Kidneys With Healthy Aging : JASN October 2017, 28 (10) 2838-2844.
18. John EO, Igbinedion BO, Akhigbe AO. Comparative Sonographic Assessment Of Renal Dimensions And Clinicobiochemical Parameters Among Diabetic And Nondiabetic Adults In Benin City, Nigeria. J Med Trop 2018;20:17- 23.