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Estimation of Renal Volume in Transplantation Donors and Correlation with Differential Renal Functions, Body Mass Index, Age and Sex.

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ABSTRACT

Knowledge of kidney size is important for the clinical assessment of renal disease. The purpose of our study was to estimate normal renal volumes in transplantation donors and to correlate with differential renal functions, BMI, Sex and Age.
84 healthy voluntary renal donors were enrolled in to the study from Aug 2012 to Feb 2015. Renal volume was estimated by two methods, first by CT scan and second by displacement method and the volumes obtained by the two methods were correlated with age, sex, differential renal functions and BMI. The mean renal volumes of left and right kidney in males were 143 ± 20.67ml and 130.38 ± 16.82 ml and in females were 132 ± 21.26 ml and 123.56 ± 19 ml respectively. The mean renal volumes calculated by displacement method were 165 ± 20.42 ml and 152.24 ± 22.08 ml in males and females. The volume of kidney statistically correlates with split GFR, BMI, Age and Sex.

KEYWORDS Computerised Tomography, DTPA scan, Displacement method, Kidney Volumes

Introduction:

Evaluation of renal size is important in the diagnosis and management of many renal disorders since there is a close relationship between renal size and its function (Buchholz NP et al., 2000). Many studies have shown that renal size is influenced by factors such as age, ethnicity, gender, weight and height (Elkin M, 1980, Chen JJ et al., 2006, Chen JJ et al, 2002). It is also known that the left kidney is larger than the right kidney in normal adults, independent of gender (Carrasco OJ et al., 2009). Many studies also concluded that renal measurement variations occur in nephropathies due to hypertrophic process and/or atrophy (Fernandes MMR et al., 2002)

There are various methods of measuring renal size such as X-rays, Ultrasonography, Computerised Tomography (CT scan) and Magnetic Resonance Imaging (MRI Scan), each having its own advantages and disadvantages (Moorthy KH &Venugopal P., 2011). In our study we measured renal volume (by ellipsoid formula), by assessing the helical CT scan images of renal donors. Kidney volume was also measured by using displacement method after donor nephrectomy and the two volumes measured by different methods were correlated. We also assessed the Glomerular Filtration Rate (GFR) of subjects by DTPA scan and correlated volumes of the kidney with age, sex, GFR and Body Mass Index (BMI) of the patients.

Materials and methods:

A total of 84 renal donors were included in this prospective study, conducted from Aug 2012 to Feb 2015. Institutional Ethical Committee approval and informed consent from subjects were obtained for the study protocol. Height, weight and BMI of all subjects were noted before subjecting the patients to routine preoperative workup which included CT Scanning of the abdomen. All the subjects were categorised into five age groups (21-30, 31-40, 41-50, 51-60 and >60).

Renal volume measurement was done by two methods, first by Ellipsoid formula ($\pi/6 \times$ **length×width×thickness**) (Kang KY et al., 2007) after renal morphometric measurements which were done by single urology resident with the help of expert radiologist by assessing CT Scan images of these subjects, and in the second method renal volume was measured in the operation theatre after donor nephrectomy using Displacement method.

Renal Volumes obtained by two different methods were correlated using Pearsons Correlation Test and P value of less than 0.05 was considered statistically significant. Correlation of renal volume measured from 3D CT scan was also done with Age, Sex, BMI and differential renal functions.

Results
Out of 84 donors, 43 subjects were males and 41 were females. The mean ages of the patients were 41 ± 9.5 years. All the subjects were categorised into five age groups as shown in the **Table1**

Table 1

Age in years	No. of patients	Males	Females
21-30	10	09	01
31-40	23	04	19
41-50	37	19	18
51-60	09	06	03
>60	05	05	0
Total	84	43	41

The BMI of the subjects ranged from 19 to 31 with mean value of 24.70 ± 3.40. The mean renal volumes (calculated by CT Scan using Ellipsoid formula) of left and right kidney in males were 143 ± 20.67ml and 130.38 ± 16.82 ml and in females were 132 ± 21.26 ml and123.56 ± 19 ml respectively. The mean renal volumes calculated by displacement methods were165 ± 20.42 ml and 152.24 ± 22.08 in males and females.

Renal Volume versus Age:
In our study, there were 10 individuals in their 3rd decade of life, 23 in the 4th, 37 in the 5th, 9 in the 6th, and 5 in the 7th decade of life. In all cases renal volumes increased with age till the 4th decade, remained more or less stable through the middle age, and then declined beyond the 6th decade probably due to age related nephron atrophy.

The mean renal volume in various age groups and as per gender is shown in **Table 3**

Table 3

	Males		Females	
Age in years	**Left kidney Volume in ml** ± SD	**Right kidney Volume in ml** ± SD	**Left kidneyVolume in ml** ± SD	**Right kidney Volume in ml** ± SD
21-30	138 ± 20.67	124.42 ± 18.06	128.20 ± 16.08	120 ± 16.20
31-40	140 ± 19.20	128 ± 20.42	134.8± 18.06	123 ± 20.42
41-50	148 ± 20.67	130 ± 16.82	134 ± 21.4	128.56 ± 19
51-60	146.42 ± 18.14	130.48 ± 18.06	130 ± 20.08	124 ± 20.08
>60	134.20 ± 18.43	122 ± 18.64	126 ± 18.20	118 ± 18.24

The mean renal volume calculated by displacement method was165 ± 20.42 ml and 152.24 ± 22.08 ml in males and females.

Renal volume versus Gender and GFR
In our study, the volume of both right and left kidneys were higher among males compared to females (P<0.003) as shown in **Table 3**

In male subjects, the fractional GFR of left kidney was 54.30 ± 6.50 ml/min and that of right kidney was 53.46 ± 6.13 ml/min; the total GFR being 108.42 ± 12.16 ml/min. In female subjects, the fractional GFR of left kidney was 53.56 ± 5.67 ml/min and that of right kidney was 52.56 ± 5.56 ml/min; the total GFR being 106.74 ± 11.23ml/min.

There was strong correlation of renal volumes with split GFR in both left and right kidney in either sex (P<0.001).

Renal size versus Body mass index:
Information on body mass index (BMI) was available in all 84 subjects, who were then divided into 3 groups, i.e., BMI 10-20, 21-30 and 31-40. The mean BMI was 23.42 ± 2.74 and 24.7± 3.40 in male and female subjects.

On correlating renal volumes with BMI, strong correlation was seen between the two (P=0.0081) as shown in the scatter diagram below in **Figure 1**

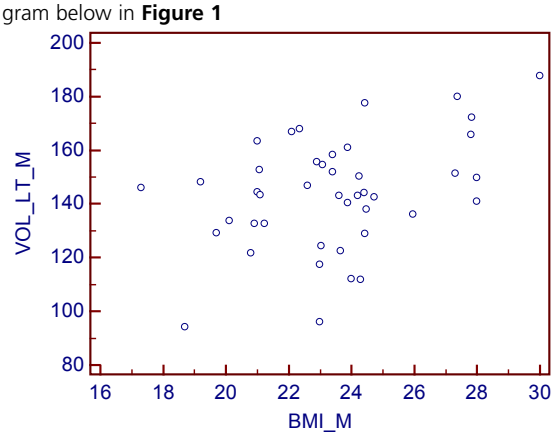

FIG 1 Scatter diagram showing correlation of renal volumes with BMI

Discussion:
Donor nephrectomy setting gave us a unique opportunity to study the accuracy of various methods of estimating renal volumes in normal adults, by comparing the renal volume measured by CT scan with the actual size which could be measured at the time of donor nephrectomy.

In our study, it was observed that males had greater body indices (height, weight, body surface area and total body water) and kidney sizes, kidney weights and kidney volumes than females. There was a significant relationship between body mass index (BMI) and actual renal volume calculated by both methods (P=0.0081). These findings indicate that physical characteristics are important determinants of kidney size.

Hackstein N et al in his study found a strong linear relationship between differential renal function by dynamic CT using modified Patlak graphic analysis, nuclear renal scan and 24-hour creatinine clearance. But it had certain disadvantages like it needed assumption of functional renal homogeneity as it involves only a particular section of kidney, complex calculations and nonavailability of the software everywhere.(Hackstein N et al .,2004)

Ng et al. in his study compared differential renal parenchymal volume with 24-hr creatinine clearance by percutaneous nephrostomy in obstructed units and found correlation between differential renal function with differential creatinine clearance (NG C ET AL.,2004)

Herts et al. in their study proposed that estimated GFR by CT-based parenchymal volume can replace GFR measurement by ^{125}I-iothalamate clearance imaging after studying 244 renal donors (Herts B et al .,2009)

In our study, the mean renal volume calculated by displacement method was more than the volume calculated by CT scan (using Ellipsoid formula) by about 15-25% probably because of extra weight of hilar vessels, ureter and renal sinus fat, although in previous study by Benjamin et al, it was seen that Ellipsoid formula underestimates the actual renal volume calculated by water displacement method by 17 to 29 % .It was also observed that renal volumes correlated significantly and positively with differential renal functions, BMI, Age and Sex.

The main strength of this study was that it was done prospectively with the intention of producing normal population data for renal dimensions. All morphometric measurements were done by the same operator with a pre defined technique to ensure maximal homogeneity; Care was also taken to ensure that none of the subjects were known diabetics or hypertensives, as these conditions and their treatment can affect kidney volumes. .

One limitation of our study was that it focused on linear renal parameters and did not involve calculation of renal volumetric data due to non availability of 3D volumetric software at our institute.

Conclusion

Our study showed that renal volume calculated by displacement method was more than volume calculated by CT scan and there is strong positive correlation of renal volumes with split GFR ,Age, gender and BMI.

REFERENCES

1. Benjamin C, Raja M, Mario FR et al. Normal Values for Renal Length and Volume as Measured by Magnetic Resonance Imaging. Clin J Am Soc Nephrol 2007:2;38-45 | 2. Buchholz NP, Abbas F, Biyabani SR, Talati J, Javed Q, Afzal M et al. Ultrasonographic renal size in individuals without known renal disease. J Pak Med Assoc 2000;50:12-16 | 3. Carrasco OJ, Castellanos RF, Kimura E, Hernandez DR and Felix HJP. Renal length by ultrasound in adult Mexican population. Nefrologia 2009;29(1):30-34 | 4. Chen JJ, Pugach J, Patel M, Luisiri A, Steinhardt GF. The renal length nomogram: a multivariate approach. J Urol 2002;168 (5):2149-52 | 5. Chen JJ, Zhi J, Mao W and Steinhardt GF. MR Nomogram web-based multivariable pediatric renal nomogram. J Ped Radiol 2006;2(5):436-38 | 6. Elkin M. Kidney size. In : Radiology of the urinary system. Ed: Elkin M, Little, Brown and Company, Boston 1980:1014-32 | 7. Fernandes MMR, Lemos CCS, Lopes GS, Madeira EPQ, Santos OR, Dorigo D et al. Normal renal dimensions in a specific population. Int Braz J Urol 2002;28(6):510-15 | 8. Hackstein N, Wiegand C, Rau W and Langheinrich AC. Glomerular filtration rate measured by using triphasic helical CT with two point Patlak plot technique. Radiology 2004; 230:231. | 9. Herts B, Sharma N, Lieber M, Freire M, Goldfarb DA and Poggio ED. Estimating glomerular filtration rate in kidney donors: A model constructed with renal volume measurement from donor CT scans. Radiology 2009; 252:109-16. | 10. . Kang KY, Lee YJ, Park SC, Yang CW, Kim YS, Moon IS et al. A comparative study of methods of estimating kidney length in kidney transplantation donors Nephrol Dial Transplant 2007; 22: 2322-7. | 11. Moorthy KH, Venugopal P. Measurements of renal dimensions in vivo: A critical appraisal. Ind J Urol 2011:27(2):169-74 | 12. Ng C, Chan L, Wong KT, Cheng CW, Yu SC and Wong WS. Prediction of differential creatinine clearance in chronically obstructed kidneys by non contrast helical computerized tomography. Int Braz J Urol 2004;30:102-7 |