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Original Research Article

To Compare the Kidney Dimensions in Healthy Individuals with Acute and Chronic Pyelonephritis Patients Using CT Scan as an Imaging Modality

Hania Siddiqui[*1], Shaista Shaukat[1], Iffar Raza[2], Samira Faiz[3], M Nadeem Siddiqui[4], Tariq Mehmood[5]

[1]*Department of Radiology, Jinnah Post Graduate Medical Center, Karachi, Pakistan*
[2]*Department of Anatomy, Karachi Institute of Medical Sciences, Karachi, Pakistan*
[3]*Department of Community Medicine, Karachi Institute of Medical Sciences, Karachi, Pakistan*
[4]*Department of Anatomy, Hamdard Medical and Dental College, Karachi, Pakistan*
[5]*Cyberknife and tomotherapy JPMC, Karachi, Pakistan*
**Corresponding author`s email address:* sidiquihania@gmail.com

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Abstract: *Acute or chronic pyelonephritis is a common renal pathology that can lead to significant kidney morphological changes. Accurate assessment of renal dimensions using imaging modalities such as computed tomography (CT) is essential for diagnosis and management. However, limited data on normal kidney dimensions and their variation in pyelonephritis in the adult Pakistani population are available.* ***Objective:*** *To compare normal kidney dimensions in healthy individuals with those in patients diagnosed with acute and chronic pyelonephritis on CT scan in the adult Pakistani population, and to correlate kidney size with age and gender.* ***Methods:*** *This case-control study was conducted at the Radiology Department of Jinnah Postgraduate Medical Centre, Karachi, over six months from September 2023 to February 2024. A total of 126 adults were included using a consecutive non-probability sampling technique: 77 healthy individuals (controls) and 49 patients diagnosed with acute or chronic pyelonephritis based on CT findings. Renal dimensions were measured using axial, coronal, and sagittal slices from multislice CT scans. Kidney lengths and transverse diameters were recorded. Statistical analysis was performed using the independent t-test to compare kidney dimensions between cases and controls and acute and chronic pyelonephritis groups. A p-value < 0.05 was considered statistically significant.* ***Results:*** *The mean age of patients with pyelonephritis was 45.8 ± 12.0 years. The mean transverse diameter of the right kidney in pyelonephritis cases was significantly larger (5.05 ± 0.18 cm) compared to controls (4.34 ± 0.06 cm) (p = 0.001). Among the pyelonephritis group, the mean transverse dimension of the left kidney in acute cases was 5.52 ± 1.00 cm, significantly larger than in chronic cases (4.44 ± 1.05 cm) (p = 0.001). Similarly, the right kidney in acute pyelonephritis had a mean transverse diameter of 5.52 ± 1.20 cm compared to 4.48 ± 0.65 cm in chronic pyelonephritis (p = 0.001).* ***Conclusion:*** *The study demonstrated that kidneys in patients with acute pyelonephritis are significantly swollen, whereas chronic infections are associated with renal atrophy. Additionally, the parenchymal thickness in pyelonephritis patients was significantly greater than in healthy controls. CT imaging is reliable for distinguishing between acute and chronic renal changes in pyelonephritis based on kidney dimensions.*

Keywords: CT scan, Kidney Dimensions, Pyelonephritis

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Introduction

Both kidneys vary in size, which is measured by sonography, CT scanning, or magnetic resonance imaging. Body size (height, weight, body mass index) and kidney size are positively correlated in some studies (1). The greater the body size, the larger the kidneys. In an adult kidney, the pole-to-pole average length is 10-13 cm, and the transverse (TN) diameter is 5 to 7.5 cm. The left kidney is smaller in size than the right kidney.

The urinary system and renal parenchyma are affected by an acute kidney infection, Acute pyelonephritis (APN), often caused by ascending bladder infections (2). It is usually accompanied by flank or suprapubic pain, high-grade fever, dysuria, frequent urination, vomiting, and nausea in patients. Recurrent infections or urine reflux from an infection during childhood can cause chronic pyelonephritis. This condition can be described by asymmetry in the kidneys as a whole, clubbing of the calyces due to papilla retraction from surrounding overlying renal scarring, hypertrophy of residual normal parenchymal tissue, and parenchymal atrophy of the affected areas (3).

Escherichia coli is the primary pathogen that causes APN. This pathogen frequently results in severe inflammation and both long-term morbidities, such as irreversible renal scarring, and short-term ones, such as fever, dysuria, and flank pain (4). Renal scarring markedly increased the Chances of end-stage renal disease and chronic kidney disease, vesicoureteral reflux (VUR), proteinuria, and hypertension. Since 37% of APN children experience renal scarring two years after the infection first appears, prompt diagnosis and the application of efficient treatment strategies are essential to the management of this illness in children (5).

An increase in kidney size is one of the primary signs of APN. Additionally, kidneys with two collecting systems are usually 1-2 cm longer than kidneys with a single pelvicalyceal system (12, 13). Renal ischemia can cause unilateral size change, and reduced kidney size is observed in systemic renal diseases (6).

An accurate preoperative diagnosis and appropriate management can be achieved by combining ultrasound, CT, and MRI scanning features to assess pyelonephritis, particularly when complicated, for instance, XGP in its focal form, which mimics or is even associated with renal carcinoma (7). Kidney biopsies are invasive procedures, and urine cytology is frequently nonspecific. Radiologists can recommend an identification of complicated pyelonephritis with a possibly benign course, avoiding needless radical therapy.

Patients undergo CT scans for various reasons. Kidney length is one parameter measured and assessed in CT scan reports. Thus, it is critical to understand the accurately computed length (8).

The current prospective study aimed to establish a reference range for normal renal dimensions in a healthy adult population and acute and chronic pyelonephritis patients, as well as the correlations between their sizes.

Methodology

This case-control study was conducted in the Radiology Department, Jinnah Postgraduate Medical Centre, Karachi, using a consecutive non-probability sampling method. The study was conducted from September 2023 to February 2024. One hundred twenty-six individuals, including 77 controls, healthy individuals visiting the radiology department for other health problems and functional kidneys, were identified and added after informed consent. While cases included 49 patients confirmed/ diagnosed with acute and chronic pyelonephritis referred from the nephrology department, validated on CT scans, were included in the study. Conversely, the study did not include patients with congenital renal diseases, chronic kidney disease (CKD), dialysis patients, patients with solitary kidneys, or patients with urinary complaints or obstruction two months prior to a CT scan.

After getting informed consent, demographic details of patients such as gender, age, coexisting illnesses, and clinical features associated with pyelonephritis were documented via questionnaire. Using axial, coronal, and sagittal slices in multislice CT made determining the kidney's actual length simple. Initially, this was determined using the standard technique, which was based on the width of the transverse diameter on the console and the distance between the upper and lower poles of the kidneys in coronal cuts in the craniocaudal (CC) region. No interventions or contrast were administered to the participants, ensuring their safety. The patients were informed about kidney pathology and subsequently directed to a urology clinic for additional care.

Data was analyzed using SPSS version 24. Frequencies and percentages were presented for categorical variables such as age, gender, clinical presentations, and coexisting illnesses. Means and standard deviations were documented for the continuous variables, such as kidney dimensions. An independent t-test was applied between cases and controls in kidney dimensions in acute and chronic pyelonephritis patients. A p-value of < 0.05 was considered statistically significant.

Results

A total of 126 individuals, of whom 49 had acute and chronic pyelonephritis and 77 were healthy controls, were included in the study. The mean age of cases with pyelonephritis was 45.8 ± 12.0 years, and the mean age of controls was 32.4 ± 13.0 years. The gender distribution showed a predominance of females among both controls, 56(72.7%), and cases, 32(75.3%). Clinical presentations such as fever and flank pain were absent in controls but prevalent in cases 8(16.3%) and 32(65.3%), respectively. Remarkably, comorbidities such as diabetes and hypertension were considerably higher among cases than controls, with 37(75.5%) of cases having diabetes compared to 14(18.2%) among controls, and 12(24.5%) of cases having hypertension compared to 3(3.9%) among controls, as shown in Table-1.

The dimensions of the right and left kidneys in cases and controls showed that among the cases, comprising 38.8% of the total participants, the mean dimensions of the right kidney in the cranio-caudal diameter were 9.55 ± 0.25 cm. In contrast, in controls, representing 77(61.2%) of the participants, it measured 9.67 ± 0.09 cm with a statistically insignificant difference (p =0.617). In the transverse diameter, the mean dimension of the right kidney in cases was 5.05±0.18 cm, significantly higher than that in controls, 4.34 ± 0.06 cm, with a significant association between them (p=0.001). Likewise, for the left kidney, in the cranio-caudal diameter, cases demonstrated a mean dimension of 9.70 ± 0.24 cm, while controls had a mean of 9.79 ± 0.11 cm, with an insignificant difference observed (p=0.712). However, in the transverse diameter, cases exhibited a significantly larger mean dimension for the left kidney, 5.03 ± 0.17 cm, compared to controls, 4.44 ± 0.06 cm, with a significant association between them (p=0.001), as shown in Table 2.

The dimensions of the right and left kidneys in acute and chronic pyelonephritis, specifically on the transverse diameter, were measured in 47 participants. Acute pyelonephritis accounted for 27(55.1%), while chronic pyelonephritis represented 22(44.9%). In the transverse diameter, the mean dimension of the left kidney in acute pyelonephritis cases was 5.52 ± 1.00 cm, significantly larger compared to chronic pyelonephritis cases, 4.44 ± 1.05 cm (p=0.001). Similarly, for the right kidney, acute pyelonephritis cases exhibited a mean dimension of 5.52 ± 1.20 cm, significantly higher than chronic pyelonephritis cases, which had a mean dimension of 4.48 ± 0.65 cm (p=0.001), as shown in Table 3.

Table 1: Demographic details of healthy individuals and patients with acute and chronic pyelonephritis

Variables		Controls- Mean ± SD (n=77)	Cases- Mean ± SD (n=49)
Age (years)		32.4± 13.0	45.8±12.0
Age groups	< 20	7 (9.09%)	10(20.4%)
	21- 40	32(41.5%)	28(57.1%)
	41- 60	26(33.7%)	9(18.3%)
	>60	12(15.6%)	2(4.08%)
Gender	Male	21(27.3%)	17(34.7%)
	Female	56(72.7%)	32(75.3%)
Clinical presentation	Fever	0(0.0%)	8(16.3%)
	flank *pain*	0(0.0%)	32(65.3%)
	Malaise	0(0.0%)	4(8.16%)
	nausea/ vomiting	0(0.0%)	5(10.2%)
Comorbidities	Diabetes	14(18.2%)	37(75.5%)
	Hypertension	3(3.9%)	12(24.5%)
	Chronic Kidney Disease	0(0.0%)	0(0.0%)
	No other illness	60(77.9%)	0(0.0%)

Table 2: The right and left kidney dimensions in cases and controls in transverse and craniocaudal diameter

Kidney Dimension in cases and controls		n(%)	Mean ± SD	*P*-value
Right Kidney CC (cm)	Cases	49(38.8%)	9.55 ± 0.25	0.617
	Controls	77 (61.2%)	9.67 ± 0.09	
Right Kidney TS (cm)	Cases	49(38.8%)	5.05 ± 0.18	0.001
	Controls	77 (61.2%)	4.34 ± 0.06	

Left Kidney CC (cm)	Cases	49(38.8%)	9.70 ± 0.24	0.712
	Controls	77 (61.2%)	9.79 ± 0.11	
Left Kidney TS (cm)	Cases	49(38.8%)	5.03 ± 0.17	0.001
	Controls	77 (61.2%)	4.44 ± 0.06	

Table 3: The right and left kidney dimensions in acute and chronic pyelonephritis on transverse diameter

Variables		n(%)	Mean ± SD	*P*-value
Pyelonephritis Left kidney TS (cm)	Acute	27(55.1%)	5.52 ± 1.00	0.001
	Chronic	22 (44.9%)	4.44 ± 1.05	
Pyelonephritis Right kidney TS (cm)	Acute	27(55.1%)	5.52 ± 1.20	0.001
	Chronic	22 (44.9%)	4.48 ± 0.65	

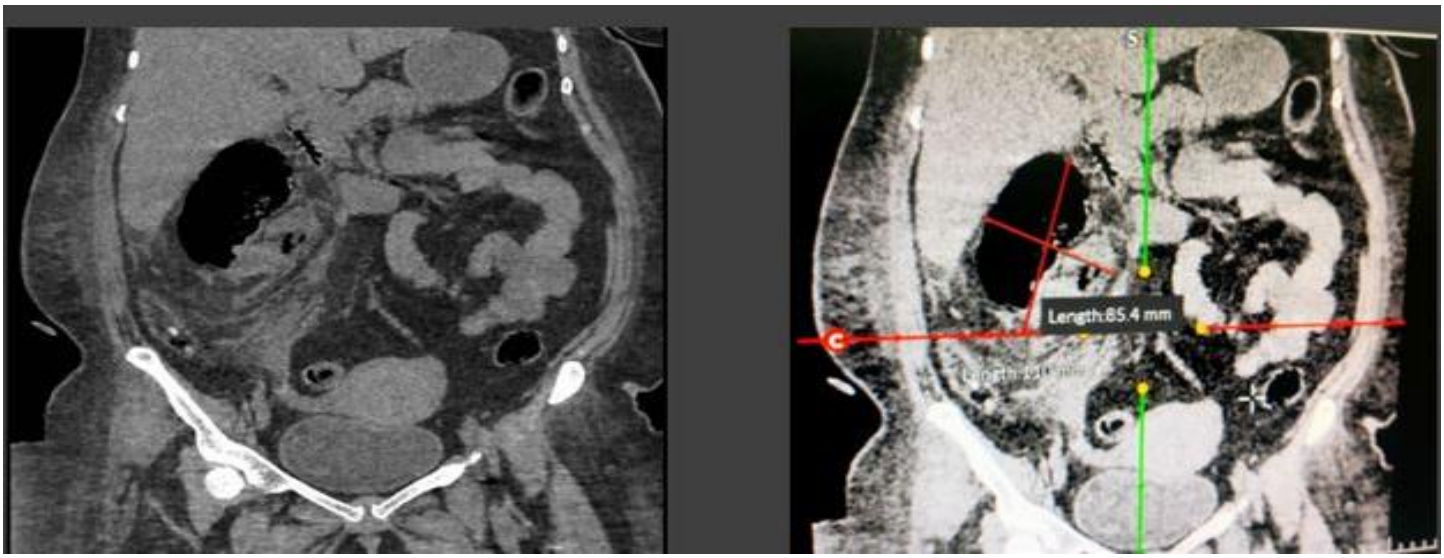

Figure A-1: CT scan images of a 39-year-old female with acute flank pain and fever showing unilateral emphysematous pyelonephritis, consistent with acute pyelonephritis.

Figure A-2:
CT scan images of a 50-year-old female with bilateral flank pain showing a shrunken left kidney and compensatory hypertrophy of the right kidney, indicative of chronic pyelonephritis.

Discussion

The kidney's size is one of the most reliable indicators and readily researchable when assessing the urinary system, so knowing the correct and current values is important for a radiologist.

Renal size varies from person to person due to many factors, including diseased state (as depicted in acute and chronic pyelonephritis patients), physiological processes, and anthropometry. 9-10 Kidney disease is an important factor that may affect kidney size. If changes in kidney size provide indications of a renal problem, further investigations can be performed to determine kidney disease.

According to Alyami et al, most research has used craniocaudal kidney length to predict kidney disease or normal function. Also, in clinical practice, the most commonly utilized and accurate measurement is the CT scan-based kidney length (bipolar measurement) linked to renal function. Whereas our study contradicts these findings and demonstrated that when the kidney size of acute and chronic pyelonephritis patients was compared, a difference was noted in transverse diameters; however, the comparison of craniocaudal dimensions of both right and left kidneys was found to be statistically nonsignificant.

Therefore, CC diameter is affected by many factors, as it is a dynamic parameter. The distinguished renal pelvic configurations lead to its variable measurements. It does not promptly demonstrate the degree of hydronephrosis. Therefore, transverse diameter (width) is a reliable tool for assessing pyelonephritis (11, 12).

CT pyelogram can provide a more detailed assessment of kidney size, shape, and position than standard X-ray and is superior when assessing acute or chronic disease changes. One of the studies compared 96 kidneys detected to have pyelonephritis on US KUB/ CT scan, and also studied their demographics. The mean age of the patients was 48.7 years, and 62% were female, with fever, flank pain, and urinary complaints as common symptoms, which was consistent with our study. Each patient had a US abdomen; in 66%, the results were suggestive of APN and later assessed on CT abdomen; 70% of those patients had PN detected on CT scan. Of these, 4% of patients had emphysematous PN (EPN), and 3% had renal abscesses. The recognition of certain PN features, such as emphysematous changes and renal abscesses, was superior on CT scans compared to USG.22 Hence, non-contrast CT scan KUB can detect emergency cases of acute pyelonephritis that need urgent nephrectomy as the treatment of choice (13, 14).

Furthermore, Karami et al in one study reported evidence linking both kidneys in 100 healthy patients and determining the difference in kidney sizes. The length of the kidneys was measured using coronal and sagittal cuts obtained from a multislice CT scan. When the actual sizes of the right and left kidneys were compared on axial sections, there was a slight difference in average length between the right and left kidneys. The mean length values in the spiral CT scan were 98.61 ± 15.8 mm and 103.11 ± 15.9 mm, respectively. The projected sizes obtained from multi-slice CT scans differed slightly for both the right and left kidneys in coronal and axial images (9.77 ± 1.19 mm and 6.63 ± 0.8 mm, respectively; $p < 0.001$). These findings were corroborated by the present study and revealed that there was only a slight variation in the craniocaudal diameter of right and left kidneys in coronal cuts. Similarly, the transverse diameter remained the same when the right and left kidney size was compared in healthy patients (controls). However, there was a difference noted in the diseased patients (cases) of the study, among which the mean transverse dimension of the left kidney in acute pyelonephritis cases was 5.52 ± 1.00 cm, significantly larger compared to chronic pyelonephritis cases, 4.44 ± 1.05 cm (p=0.001). Similarly, for the right kidney, acute pyelonephritis cases exhibited a mean dimension of 5.52 ± 1.20 cm, significantly greater than chronic pyelonephritis cases, which had a mean dimension of 4.48 ± 0.65 cm (p=0.001) (15-17).

Moreover, numerous studies have highlighted the relationship between kidney size and demographics. When compared with cases and controls, a significant difference was observed in the transverse diameter of both right and left kidneys in healthy patients. Advanced age can be used to classify PN or predict the prognosis, and it is easily recognized during the initial presentation of PN (18, 19).

Rollino C et al. and Kumar S et al conducted studies which demostrated females prevalence of PN Mean age of patient were 48.7 years (range 15 – 85), majority of them were more than 40 years, by The present study showed partly similar results as the above-cited studies and revealed that the gender distribution showed a female predominance over males in both cases and controls, however, mean age of cases with pyelonephritis was 45.8 ± 12.0 years, but the mean age of controls, was 32.4 ± 13.0 years (p=0.001) which is justified according to our results as the kidneys affected by disease process belonged to older patients whereas younger age group had unremarkable kidneys (20–22).

After the literature review, it was evident that international data were available on the interpretation of kidney size and its comparison on CT scan as discussed above. However, there was a lack of similar studies in Pakistani literature, which makes the study more valuable and adds new work to the scientific literature. The current case control study provided accurate results regarding kidney dimensions on a non-contrast CT scan, which can benefit a clinician/ specialist.

Lastly, the study had some limitations. One limitation of this study was that it was a single-center study; different institutions may have provided variable data. Secondly, the small sample size resulted in it being performed only in 126 patients. Therefore, a larger population is required to determine normal values. Pezeshki et al evaluated the kidney dimensions in 938 healthy individuals on ultrasound, which is a massive number (23, 24). Another limitation is that a single radiologist took these measurements on PACS; therefore, an inter-observer study is recommended. Also, the demographics did not include weight, height, and BMI.

Conclusion

Knowing the true measured values of kidney size is of particular importance to different types of medical imaging. This study concluded that patients with acute pyelonephritis have severely inflamed kidneys with a larger diameter, whereas patients with chronic infections have smaller kidneys. Furthermore, the parenchymal thickness of the right and left kidneys in patients with pyelonephritis was considerably greater than in the control group. Therefore, kidney size may be a significant factor associated with the development of pyelonephritis.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-JND-2171-23)

Consent for publication
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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

***HS** (PGR), **SS** (HOD)*
Manuscript drafting, Study Design,
Study Design, manuscript review, critical input
***IR** (Associate Professor), **SF (**Associate Professor)*
Review of Literature, Data entry, Data analysis, and article drafting.
***MNS** (Professor), **TM** (Professor)*
Conception of Study, Development of Research Methodology Design.

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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