Original Article

Analysis of Lower Pole in Normal Healthy Kidneys

Morphometric Analysis of Lower Pole Calyceal Anatomical Factors in Normal Healthy Kidneys and Their Clinical Significance

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ABSTRACT

Objective: To measure anatomical factors particularly in relation to the lower pole calyceal anatomy of normal healthy kidneys in our population in order to find their clinical significance.
Study Design: Observational / Cross-sectional study
Place and Duration of Study: This study was conducted at the Department of Anatomy, Watim Dental College, Rawat, Department of Urology, Shaafi International Hospital, Islamabad and Department of Radiology, Al-Nafees Medical College & Hospital, Islamabad from July 2015 to April 2017.
Materials and Methods: 25 healthy kidney donors between 18 – 60 years aged, who were referred to the kidney transplant service at Shaafi International Hospital, Islamabad having normal renal function, coming through ethical and official processes of kidney donation, and submitting a written consent were included. A total of 50 kidneys (from 25 IVU films) were available for the purpose of this study. The source of IVU films was from Radiology department. The data was collected using predesigned, pretested Pro-forma. The parameters measured were Lower Calyceal Infundibular Length (LCIL), Lower Calyceal Infundibular Width (LCIW) and Lower calyceal infundibulo – ureteropelvic angle (LCIUPA). Obtained data was presented as range, mean ± standard deviation, and percentage (%) distribution. Microsoft Excel program version 2016 was used for statistical analysis.
Results: The mean age was 26.9 ± 6.8 years (minimum age was 20 years and maximum age was 41years). The mean LCIL was 26.9 ± SD of 6.8 and mean LCIW was 8.6 ± SD of 2.4. The mean LIUPA was 53.6 ± SD of 23.3.
Conclusion: Measurement of lower calyceal anatomical factors is essential in order to identify favourable and unfavourable factors in management of lower calyceal renal stones. Knowledge of these factors is of immense value in deciding best method of treatment of lower calyceal stones in a patient for a successful outcome. Further studies are needed in a 3 dimensional views of renal pelvicalyceal anatomy in order to reflect the data more accurately.
Key Words: Lower calyx, Infundibular Length, Infundibular Width, Infundibulo ureteropelvic Angle, Anatomy.

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INTRODUCTION

Renal collecting system comprises three major calyceal systems namely upper, middle and lower calyces that arise from the renal pelvis each of which then are subdivided into three to five minor calyces. Morphology of renal collecting system has many variations. Although, the arrangement of renal collecting system are similar on both sides in an individual, at times there are variations on each side of a particular individual.

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Kidney stones are a common problem and can form in any part of the renal collecting system but they are most frequent in lower pole calyx.

Although gravity was initially thought to be the main factor in lower calyceal stone formation, but it does not explain, why a single stone forms on one side and not in the other kidney in a same person, thus suggesting the possible role of lower calyceal special anatomical factors also as a cause [1]. In view of this, it is very logical to consider different pelvicalyceal properties as the key factor in lateralization of the stone and also as a risk factor for their formation [2].

Kidney stone treatment modalities have been revolutionized recently with plethora of minimally invasive techniques which require detailed knowledge of pelvicalyceal anatomy. In addition such knowledge play an essential role in the selection of best method of kidney stone treatment for a particular patient. In this modern era of urological procedures for management of renal stones such as Extracorporeal Shock Wave Lithotripsy (ESWL), Flexible Ureterorenoscopy, Retrograde Intra Renal Surgery (RIRS) and Percutaneous Nephrolithotomy (PCNL), the selection of best possible procedure that results in complete clearance of a kidney stone, requires detailed analysis of pelvicalyceal anatomy of the involved kidney [3].

Intravenous Urography (IVU) is considered to be the procedure of choice when anatomical details of the pelvicalyceal anatomy is required [4], although other studies have suggested the use of Computed Tomographic Urography (CTU) with comparable results [5].

Review of the available literature revealed that studies usually measured several anatomical factors such as infundibular length, infundibular width, infundibulo - ureteropelvic angle and lower pole ratio mostly for lower pole calyx. These anatomical parameters are now considered to have a significant impact on stone formation and recurrence [1, 5-6]. In addition, an analysis of these parameters would indicate the likely effectiveness of a chosen method of treatment. Lower calyceal infundibulo-pelvic angle is the most important factor that can predict the stone clearance status after extracorporeal shockwave lithotripsy in adults[7] and children[8], although some studies are non-suggestive of this factor[9].

Although, some data for our population for ultrasonographic assessment of renal size and cortical thickness is available[10], but few studies have been done in the knowledge of detailed anatomy of pelvicalyceal system in local settings[3, 21].

MATERIALS AND METHODS

In this cross-sectional study, 25 healthy kidney donors who were referred to the kidney transplant service at Shaafi International Hospital, Islamabad (July 2015 through April 2017) were included. Inclusion criteria included were: Age 18–60 years, having normal renal function, coming through ethical and official processes of kidney donation, and submitting a written consent. Exclusion criteria included poor image quality on IVU, kidneys with duplicated renal artery and vein, kidneys with renal stones, kidneys having large cysts and pelvic kidney. A total of 50 kidneys (from 25 IVU films) were included in this study.

The source of IVU films was from Radiology department. The data was collected using predesigned, pretested Pro-forma. The parameters measured were as follows:

1. Lower Calyceal Infundibular Length (LCIL)
   This length is the distance measured from the most distal point at the bottom of the lower calyx to a midpoint of the lower lip of the renal pelvis [11].
2. Lower Calyceal Infundibular Width (LCIW)
   This width was measured at the narrowest point along the respective infundibular axis.
3. Lower calyceal infundibulo – ureteropelvic angle (LCIUPA)
   The infundibulo-ureteropelvic angle (IUPA) was measured between infundibular and ureteropelvic axes.

The 3 major radiographic features of the lower pole calyx were easily measured on standard IVU using a ruler and protractor.

All the measurements were done according to the method described by Elbahnasy et al. [12] (Fig. 1).

Obtained data is being presented as range, mean ± standard deviation, and percentage (%) distribution. Microsoft Excel program version 2016 was used for statistical analysis.

RESULTS

A total of 50 normal kidneys of healthy kidney donors (from 25 IVU films) were studied. The mean age was 26.9 ± 6.8 years (minimum age was 20 years and maximum age was 41 years).

a. (LCIL) b. (LCIW) c. (LCIUPA)

Figure No.1: a. (LCIL) b (LCIW) C. (LCIUPA)

The result of all lower calyceal parameters observed are shown in table.

The mean LCIL was 26.9 ± SD of 6.8 and mean LCIW was 8.6 ± SD of 2.4. The mean LIUPA (as measured according to Elbahnasy method) was 53.6 ± SD of 23.3.

Table No.1: Analysis of variables of lower calyceal anatomical factors

Variables	No of kidneys	Range	Mean	SD
LCIL (mm)	50	10.4 – 45.8	26.9	6.8
LCIW (mm)	50	4.1 – 16.6	8.6	2.4
LCIUPA (degree)	50	17 – 129	53.6	23.3

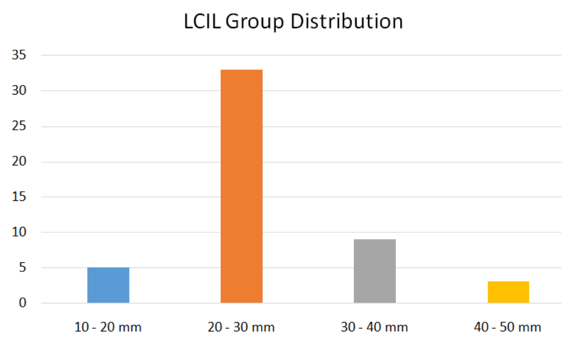
LCIL: Lower Calyceal Infundibular Length, **LCIW**: Lower Calyceal Infundibular Width, **LCIUPA**: Lower Calyceal Infundibulo Uretero Pelvic Angle

Frequency distribution of all three observed parameters are described in graphs 1 – 3.

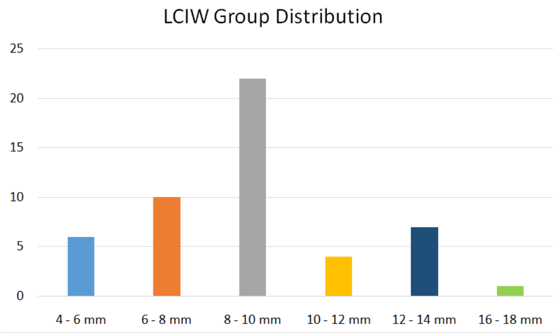
A majority of 33 kidney units (66%) had lower calyceal infundibular length in the range of 20 – 30 mm as depicted in graph 1.

A total of 22 kidney units (44%) had lower calyceal infundibular width in the range of 8 – 10 mm as shown in graph 2.

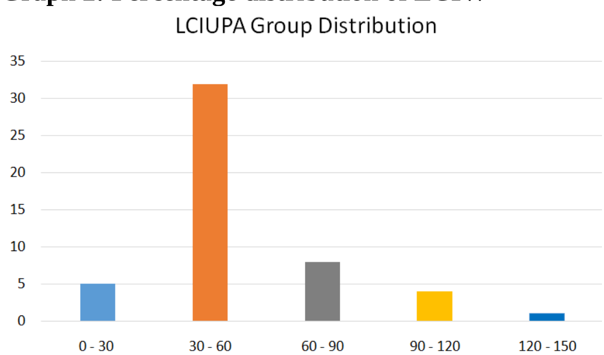
A total of 32 kidney units (64%) had lower calyceal infundibulo ureteropelvic angle in the range of 30 – 60 degree shown in graph 3.



Graph No.1: Percentage distribution of LCIL



Graph 2: Percentage distribution of LCIW



Graph No.3: Percentage distribution of LCIUPA

DISCUSSION

The investigations of the relationship between pelvicalyceal anatomical features and urolithiasis started with the pioneering study of Sampaio & Aragão[1]. After that, several studies analysed the pelvicalyceal factors although these studies were generally interested in stone clearance of lower calyceal stones after SWL rather than in its etiologic role[6,9,12]. In these studies, several anatomical factors, such as infundibular length, width and infundibulopelvic angle were measured and lower pole ratio was calculated on intravenous urogram. Sampaio & Aragão concluded that an angle of less than 90-degrees between lower pole infundibulum and pelvis, multiple calyces and a calyceal width < 4 mm might lead to retention of residual stones in lower calyceal group after lithotripsy[1]. Similarly most studies agreed that the calyceal anatomy was an important risk factor for lower pole stone clearance after SWL[6,12], however opposite opinions also exist [9].

In our present study the mean LCIL was 26.9 mm. It varies from 10.4 – 45.8 mm and it was 20-30 mm in 66% (Graph no. 1). According to Fong Y.K. et al[6] and Gupta N. P. et al[13] the mean LCIL was 21.7 ± 6.9 mm in 60.8% & ≤ 30 mm in 77% respectively. Both studies concluded better stone clearance after Lithotripsy in these kidneys. However, in a similar study, Madbouly K. et al[9] found that the mean LCIL was 20.9 +/- 6.56 mm which had no impact on stone clearance after 3 months of lithotripsy.

In our study the mean LCIW was 8.6 mm. It varies from 4.1 – 16.6 mm and it was 8 -10 mm in 44% (Graph no. 2). According to Sampaio F. J. B. et al [1] and Li-ping Xie et al[11], the LIW was greater than 4 mm in 60.3% and 67% respectively. Our present findings are comparable with these studies. Similarly, Gupta N. P. et al[13] found that in 75% of cases the LIW was 5 mm or more and the mean LIW was 6.75 mm.

The mean LCIUPA in our case was 53.6 degree and majority (64 %) were between 30 – 60 degrees (Graph no. 3). According to Zomorrodi A. et al[14], the mean infundibulum-uretero-pelvic angle (IUPA) in control subjects and in stone bearing study cases was 53.5 +/- 12.7 and 42.6 +/- 13.4, respectively. There was significant correlation between decreased angle and stone formation (P = or < 0.001). In another study by Ahmed E.A. et al[15], the mean infundibulum-uretero-pelvic angle (IUPA) was 52.3 degrees in stone bearing kidney and 54 degrees in normal kidneys (P = 0.36). On the other hand, Gökalp et al[16], compared 119 lower calyceal stone forming kidneys with 40 healthy controls and they concluded that lower pole IUPA was not an important factor for stone formation in lower calyx. Similarly, Khan. M et al[17] found no significant effect of lower pole IUP angle on stone free rate after lithotripsy in their series. In another study, Nabi et al[18] evaluated 100 consecutive patients with lower calyceal stones and they found that lower pole IUPA was more acute in 74% of cases in stone-forming side than the normal contralateral kidney. They concluded that IPA was a significant risk factor for lower calyceal stones.

Interpretation of pelvicalyceal anatomy from two-dimensional IVU is very difficult. A large series of three-dimensional endocasts of the kidney collecting system showed that the superior pole was drained by a single calyceal infundibulum in 98% of cases where as the inferior pole was drained by paired calices arranged in two rows in 58% of cases and by a single calyceal infundibulum in only 42% of cases[19,20].

Another important point on interpretation of pelvicalyceal variations is the different measurement techniques and interobserver variations. Proper assessment of lower calyceal features seems to be a particular problem because several authors described different methods[12,13]. A recent study showed that there were high interobserver variations among different techniques [21]. We performed our measurements with the method described by Elbahnasy et al.[12]. Additionally, quality of the imaging also bears impact on achieving reliable data.

The 3 major radiographic features of the lower pole calix (infundibulo uretero-pelvic angle, and infundibular length and width) has a statistically significant influence on stone clearance after ESWL. A wide infundibulopelvic angle or short infundibular length and broad infundibular width regardless of infundibulopelvic angle are significant favourable factors for stone clearance following ESWL[12]. Conversely, these factors have a cumulatively negative effect on the stone clearance rate after ESWL when they are all unfavourable. In flexible ureteroscopy, particular anatomy of pelvicalyceal system may have a negative impact when there is uniformly unfavourable pelvicalyceal anatomy.

CONCLUSION

Our study was a sincere effort to measure lower calyceal anatomical factors in a local population in order to identify favourable and unfavourable lower pole calyceal anatomical factors in comparison with already published series. Knowledge of these lower calyceal anatomical factors is of immense value in deciding best method of treatment of lower calyceal stones in a patient for a successful outcome.

We believe that the physician should consider these anatomical features when suggesting ESWL to treat calculi in the lower calyces. More detailed studies are needed in a 3 dimensional views of renal pelvicalyceal anatomy in order to reflect the data more accurately.

Author's Contribution:

Concept & Design of Study:	Atika Khurshid
Drafting:	Waqar Azim Niaz
Data Analysis:	Kamil Shuaat
Revisiting Critically:	Waqar Azim Niaz, Atika Khurshid
Final Approval of version:	Atika Khurshid

Conflict of Interest: The study has no conflict of interest to declare by any author.

REFERENCES

1. Sampaio FJ, Aragao AH. Inferior pole collecting system anatomy: Its probable role in extracorporeal shock wave lithotripsy. J Urol 1992;147:322–4
2. Kupeli B, Tunc L, Acar C, et al. The impact of pelvicalyceal anatomical variations between the stone-bearing and normal contralateral kidney on stone formation in adult patients with lower calyceal stones. Int Braz J Urol 2006; 32(3): 22-32.
3. Hanif MS, Toori MH, Sheikh MA. Detailed calyceal anatomy for endourology. Pak J Med Res 2004; 43(4): 184-87.
4. Pollack HM. Clinical Urography- an Atlas and Textbook of urological imaging. 1st ed. Philadelphia: WB Saunders Co; 1990.p.135-78.
5. Tarzamni MK, Nariman Nezami, and Afshar Zomorrodi, et al. Renal Collecting System Anatomy in Living Kidney Donors by Computed Tomographic Urography: Protocol Accuracy Compared to Intravenous Pyelographic and Surgical Findings. J Clin Imaging Sci 2016; 6: 1.
6. Fong YK, Peh SO, Ho SH, Ng FC, Quek PL, and Ng KK. Lower pole ratio: a new and accurate predictor of lower pole stone clearance after shockwave lithotripsy? Int J Urol 2004;11:700-3.
7. Keeley FX Jr, Moussa SA, Smith G, Tolley DA. Clearance of lower-pole stones following shock wave lithotripsy: effect of the infundibulopelvic angle. Eur Urol 1999; 36:371-5.
8. Ozgur TM, Karaoglan U, Sen I, Deniz N, Bozkirli I. The impact of radiological anatomy in clearance of lower calyceal stones after shock wave lithotripsy in paediatric patients. Eur Urol 2003; 43:188-93.
9. Madbouly K, Sheir KZ, Elsobky E. Impact of lower pole renal anatomy on stone clearance after shock wave lithotripsy: fact or fiction? J Urol 2001;165:1415-8.
10. Buchholz N, Abbas F, Biyabani S, Afzal M, Javed Q, Rizvi I, et al. Ultrasonographic renal size in individuals without known renal disease. J Pak Med Assoc 2000;50:12-6.
11. Li-ping X, Shi-fang S. Radiographic anatomical insight into mechanism of lower calyceal stone evacuation following ESWL. J Zhejiang Univ Sci 2000;1(3): 347-51.
12. Elbahnasy AM, Shalhav AL, Hoenig DM, Elashry OM, Smith DS, McDougall EM, et al.: Lower calyceal stone clearance after shock wave lithotripsy or ureteroscopy: the impact of lower pole radiographic anatomy. J Urol 1998;159: 676-82.
13. Gupta NP, Singh DV, Hemal AK, et al. Infundibulopelvic anatomy and clearance of inferior calyceal calculi with shock wave lithotripsy. J Urol 2000; 163: 24-27.
14. Zomorrodi A1, Buhluli A, Fathi S. Anatomy of the collecting system of lower pole of the kidney in patients with a single renal stone: a comparative study with individuals with normal kidneys. Saudi J Kidney Dis Transpl 2010; 21(4):666-72.

15. Ahmed El-Assmy, Mohamed E. Abo-Elghar, Ahmed R. El-Nahas, Youssef RF, Tarek El-Diasty, et al. J Endourol 2008;22(9): 2175-2180.
16. Gokalp A, Tahmaz L, Peskircioglu L, Ozgok Y, Saglam M, Kibar Y, et al. Effect of lower infundibulopelvic angle, lower infundibulum diameter and inferior calyceal length on stone formation. Urol Int 1999; 63: 107-9.
17. Khan M, Lal M, Par Kash D, Hussain M, Rizvi S. Anatomical factors predicting lower calyceal stone clearance after extracorporeal shockwave lithotripsy. Afr J Urol 2016;22: 96–100
18. Nabi G, Gupta NP, Mandal S, Hemal AK, Dogra PN, Ansari MS. Is infundibuloureteropelvic angle (IUPA) a significant risk factor in formation of inferior calyceal calculi? Eur Urol 2002; 42: 590-3.
19. Rachid D, Cavalcanti AG, Ravizzini PI, Sampaio FJ. Do intravenous pyelogram and 3-D helical CT show the same spatial anatomy of the inferior collecting system? J Endourol 2000; 14 (suppl 1): A-83; abstract P 16-3.
20. Sampaio FJ: Surgical Anatomy of the Kidney. In: Smith AD, editor. Smith's Textbook of Endourology. Part II, Percutaneous surgery. New York, Quality Medical Publishing; 1996.p.153-84.
21. Knoll T, Musial A, Trojan L, Ptashnyk T, Michel MS, Alken P, et al. Measurement of renal anatomy for prediction of lower-pole calyceal stone clearance: reproducibility of different parameters. J Endourol 2003;17:447-51.