THE IMPACT OF ANATOMICAL VARIATION OF LOWER POLE COLLECTING SYSTEM OF KIDNEY ON STONE FORMATION

Zahid Shah,[1] Abdul Sahib Khan,[2] Sohail Aziz Paracha,[2] Mohammad Tahir,[3] Mohammed Javed[1]

ABSTRACT

Objective: *To determine the effect of lower pole renal anatomy in terms of infundibuloureteropelvic angle (IUPA), infundibulocalyceal length (ICL), infundibular width (IW) on the formation of solitary stone of the lower pole of kidney in our set up.*

Methodology: *We conducted retrospective analysis of renal collecting system of 40 adult patients with non-obstructed kidney having solitary stone of lower pole. This study was carried out from January 2008 to January 2011 at Anatomy department Khyber Medical College Peshawar in collaboration with Anatomy and Surgical department of Khyber Medical University Institute of Medical Sciences (KIMS) Kohat. The morphometeric parameters of the lower pole of kidney like IUPA, ICL and 1W were measured from standard intravenous urograms. The data of stone forming and non-stone forming contra lateral side were compared. Statistical analysis was performed by paired t test.*

Results: *In 30 (72%) patients the IUPA of stone forming side was more acute than on the non-stone forming side. The difference between the stone forming and contralateral normal side was statistically significant ($P<0.05$). The mean ICL of stone forming side was 32.15±9.02 mm compared to 27.38±4.58 mm on non-stone forming contralateral side ($P<0.05$). The mean width of lower pole infundibulum was 3.16±0.8mm on stone forming side versus 6.8±1.6 mm on non-stone forming side ($p<0.05$).*

Conclusion: *Abnormal renal anatomy of lower Pole collecting system was found to be more common in patients with lower calycael stones so it is considered to be a risk factor for forming lower pole kidney stone.*

Key Words: *Pyelocalyceal Factors, Kidney Lower Pole, Stone Formation, Infundibuloureteropelvic Angle, Infundibulocalyceal Length, Infundibular Width.*

This article may be cited as: Shah Z, Khan AS, Paracha SA, Tahir M, Javed M. The impact of anatomical variation of lower pole collecting system of kidney on stone formation. Khyber Med Univ J 2012;4(2): 54-58

INTRODUCTION

Urinary stone disease is the most common urologic problem and constitutes up to half of all urologic workload in adults in Pakistan[1]. Pakistan lies in the stone belt area with reported consistently high incidence of urolithiasis[2]. Its incidence is 5%-15% in western nations and 10-15% in Pakistan[3,4]. Renal stones forms a major portion of urinary stones and silent renal stones constitutes 3% prevalence which may only be discovered incidentally or during screening[5]. Its incidence has been estimated 13% for adult men and 7% for adult women[5-7].

1 Department of Anatomy, Khyber Medical College, Peshawar, Pakistan
2 Department of Anatomy, Khyber Medical University, Institute of Medical Sciences (KIMS), Kohat, Pakistan
3 Department of Surgery, KDA Divisional Headquarter Hospital, KIMS, Kohat, Pakistan

Address for Correspondence:

Dr Zahid Shah

Department of Anatomy, Khyber Medical College (KMC), Peshawar Pakistan

E-mail: frozendroop@yahoo.com
Date Submitted: July 01, 2011
Date Revised: June 12, 2012
Date Accepted: June 14, 2012

The unilateral stones are more common than the bilateral ones[8]. Cass et al found in their survey that 25-35% of calyceal calculi are located in the inferior collecting system of the kidney[9]. Renal stone is one of the frequent causes of end stage renal disease[10] and may lead to life threatening infective complications[11]. In a study conducted in Karachi Pakistan, 20% of patients with urinary renal stone disease had compromised renal function[12]. Renal stones pose an enormous socio-economic impact[13].

Both metabolic and non-metabolic factors have been suggested as the causative factors but the pathogenesis of urolithiasis has been generally explained by the metabolic ones only which is not sufficient to explain the dilemma so various health workers have taken into consideration the other probable aetiologies like morphological features of kidney. These intrarenal anatomic variations like long length, narrow infundibulum and acute infundibuloureteropelvic angle of collecting system of the kidney especially of lower pole, have been suggested as one of the cause as these lead to poor rate of urine flow and crystal density from nephron to ureter resulting in stasis and provide nidus for stone formation. It has also been strongly suggested in case of lower pole stones especially that spatial anatomy in addition to gravity plays an important role in the stone clearance as well as stone formation. Many similar surveys have proven the role of these morphometeric factors in the genesis of renal stones in persons having anatomic variation of urinary tract[14-16]. Three dimensional helical computed tomography (3D-HCT) was being considered to be more precise but actually does not have any edge over IVU in evaluation of radiological anatomy of lower pole[17]. Extracorporal shock wave lithotripsy (ESWL) is the treatment of choice for renal stones especially for the stones of lower pole[18].

In the light of aforementioned facts and that no such study has ever been conducted in our set up on the role of pyelocalceal factors in the genesis of lower pole renal stones. We planned this study to determine the effect of lower pole renal anatomy in terms of infundibuloureteropelvic angle (IUPA), infundibulocalyceal length (ICL), infundibular width (1W) on the formation of solitary stone of the lower pole of kidney in our set up.

METHODOLOGY

This retrospective descriptive study was conducted from January 2008 to January 2011, at Anatomy Department, Khyber Medical College, Peshawar in collaboration with Anatomy and Surgical Department of Khyber Medical University Institute of Medical Sciences (KIMS), Kohat. We studied consecutive 40 adult patients of both genders with unilateral solitary radio opaque lower pole stone of non-obstructed kidney detected by ultrasound and followed by standard intravenous urogram (IVU). Three years record of the aforesaid patients was reviewed analytically.

Exclusion criteria included patients with hydronephrosis of kidney, major congenital anomalies of kidney like horse shoe, pelvic and mal-rotated kidney, bifid pelvis, bifid ureters, ectopic pelvic fusion anomalies, previous evidence of recurrent stones or renal surgery ,patients with pyelonephritic changes and cases with stent placement. Study was approved by the ethical committee of the college and hospital. Written consent had been taken from the patients for the survey and a structured proforma was used for the collection of data. Convenient sampling technique was used for the collection of sample. The spatial anatomic features like infundibuluouretropelvic angle (IUPA), the infundibulocalyceal length (ICL) and infundibular width (IW) of the lower pole of both the stone bearing and non-stone bearing contra lateral kidney were measured on standard intravenous urogram by using Elbahnasy AM et al[16] technique. All the measurements were taken by the same researcher and by using a ruler and a square. The lower pole IUPA was calculated in degrees by the angle between the infundibulum and ureteropelvic axis (Fig.1). The lower pole ICL was measured in mm from the most distal point at the bottom of the infundibulum to the middle point in the lower edge of the pelvis of kidney (Fig 2). The lower pole IW was taken in mm from the narrowest point of infundibulum (Fig. 3). An acute IUPA means (IUPA < 90°), narrow IW or diameter means (IW <4mm) and long ICL means (ICL>5 cm). The results of stone forming and non-stone forming contra lateral kidney were compared. Statistical significance for each anatomical factor was evaluated by paired t test. Data was analysed by using statistical software (SPSS14.0 version) with P<0.05 was considered as statistically significant.

TECHNIQUE OF MEASURING LOWER POLE INFUNDIBULU-URETERO PELVIC ANGLE (IUPA)

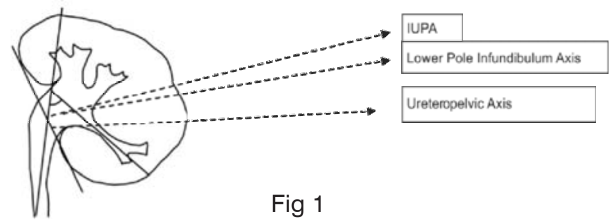

Fig 1

TECHNIQUE OF MEASURING LOWER POLE INFANDIBULAR CALCCYCEAL LENGTH (ICL)

Fig 2

TECHNIQUE OF MEASURING LOWER POLE INFANDIBULAR WIDTH (IW).

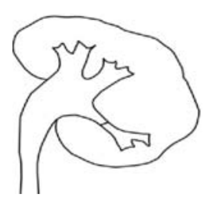

Fig 3

RESULTS

Out of 40 patients, 25(62.50%) were males and 15(37.50%) were females, with male to female ratio of 1.66:1. The age ranged from 20-70 years with mean of 39.10 ± 10.40 years. Twenty eight patients (70%) had stone on the left side and 12 (30%) on the right side. IUPA was more acute on stone bearing side than on non stone bearing side in 29(72.50%) cases depicting an association between acute angle and stone formation (p value<0.002). ICL was equal to or more than 50 mm in 24 (61%) of the cases so it was lengthier on stone bearing side than on non-stone bearing side (p value <0.001). Similarly IW diameter was equal to or less than 4mm in 27 (67%) of cases so it was found narrower on stone bearing side as compared to non-stone bearing side (p value <0.001). Comparison of range of various anatomic parameters between the stone bearing and normal contra lateral lower pole kidney is shown in the Table I. The mean of different values in the kidney with calculus and without calculus are given in Table II.

DISCUSSION

Several theories have been put forth by various investigators to explain the pathophysiology of kidney stone disease but the exact mechanism of stone formation is still unclear. Researchers have mainly focused on the metabolic risk factors only but these factors alone are not enough to explain the pathogenesis, unilaterlity and lower pole dominance of renal lithiasis. Among the non metabolic factors like intrarenal anatomical variation of collecting system has been suggested as one of the cause.[19,20] The relationship between morphological features of collecting system of kidney and urinary stone became evident from the pioneering study of Sampaio FJ and Aragao AH. [21] They found that in addition to gravity certain specific anatomic features of lower pole like acute angle (IUPA <90°), narrow infundibuluar diameter (<4mm) and infandibular length (>5 cm) are responsible for retention of debris in post ESWL cases and might play a vital role in stone formation. Nabi and colleagues mentioned in their study that anatomical factors like IUPA and IW played a significant role in stone formation and compared the results of stone forming with non-stone forming side.[22] So gravity dependent position of lower pole and unfavourable anatomy of lower pole of kidney like long length, narrow infundibulum, and acute angle (IUPA) cause delay in exit of urine, poor clearance of crystals resulting in stagnation and precipitation leading to stone formation. So these morphologic features of lower pole collecting system have been suggested as negative factors for stone clearance [14] and may play a vital role in stone formation as well.

In our study the various morphologic features of lower pole pyelocaliceal system of stone bearing and non-stone bearing contralateral normal kidneys were compared and a statistically significant difference was found in two groups in terms of IUPA, ICL and IW. A strong correlation was found between decreased IUPA angle, increased ICL length, decreased IW and stone formation. The mean values of IUPA on stone bearing and non-stone bearing other sides were 53.20 degrees and 60.22 degrees in our survey respectively. IUPA was more acute in 72 % of cases. These figures are consistent with other similar international studies where it was more acute on stone forming side in 74 % of cases reported by Nabi et al[22] while Serdger et al found in 72 % of cases.[23] It may be suggested that IUPA may be a significant parameter in the formation of lower pole calculi. The IUPA was more acute on the stone forming side, which is believed to cause stagnation and retention of crystals in the inferior calyceal system which may result in the formation of stones.

In our study the mean ICL was 32.15 mm on stone bearing side and 27.15 mm on non-stone bearing opposite side. In 61 % of cases it was 30 mm or more. Our finding of ICL is consistent with those of Elbhansy et al,[16] Afshar Zamorrodi et al,[20] Sedner et al[23] and Manikandan R et al.[24] Elbanahnasy et al[16] reported an average infundibular length of 38 mm in 34 patients, with solitary lower pole stone and their study was conducted to assess the effect of ESWL and ureteroscopy on the inferior calyceal calculi. Similarly Serdar G et al[23] reported

THE RANGE OF VARIOUS PARAMETERS OF SOLITARY STONE BEARING LOWER POLE OF KIDNEY AND CONTRALATERAL NORMAL KIDNEY (N=40)

	Non-stone bearing side	Stone bearing side
Infundibuloureteropilvic angle of lower pole in degree	30-95	26-83
Infundibulocalyceal length of lower pole in mm	16-38	20-45
Width of lower pole infundibulum in mm	4.2-11.8	2.7-5.8

Table I

COMPARISON OF MEANS OF VARIOUS PARAMETERS TAKEN IN KIDNEY HAVING CALCULUS AND CONTRALATERAL NORMAL KIDNEY (N=40)

	Non stone bearing side	Stone bearing side	P value
Mean Infundibuloureteropilvic angle of lower pole in degree	60.22 ± 17.51	53.20 ± 18.15	<0.002
Mean Infundibulocalyceal length of lower pole in mm	27.15 ± 4.58	32.15 ± 9.02	<0.001
Mean Width of lower pole infundibulum In mm	6.8 ± 1.6	3.16 ± 0.8	<0.001

Table II

mean ICL of 30.20mm in calculus containing kidney and 25.51 mm in non-calculus control group. The difference between these two values was statistically significant. It is suggested that ICL length is another negative factor causing hindrance in lower pole drainage leading to stagnation and renal lithiasis.

We found mean IW to be 3.16 mm on calculus side while 6.8 mm on non-calculus contralateral side. This finding is in accordance with findings of Nabi et al [22] and Serder et al[23] where it was 5.6mm on stone forming while 4.8 on non-stone forming side and 4.02 on stone forming while 4.22 mm on non-stone forming side respectively. Afshar Zamorrodi and colleagues [20] reported a mean IW of 6.9 mm in non-stone forming sides and 6.3mm in stone forming sides. It was clearly evident from the above studies that the narrow IW hampers the smooth passage of urine and causes stagnation in the lower pole of the kidney. Samino et al reported that an IW greater than 5mm is a favourable factor for post ESWL free stone clearance rate.[25]

The limitations of our study are absence of urodynamic studies and histological evaluation of lower pole calyceal system. Further studies of lower pole collecting system with CT scan and metabolic evaluation in larger number of cases are recommended.

CONCLUSION

Our study showed that infundibulo pelvic anatomy of lower pole of kidney plays a significant role in stone formation and various morphologic features like IUPA, ICL, and IW should be considered as risk factors which might predispose to its causation.

REFERENCES

1. Hussain M, Lal M, Ali B, Naqvi SA, Rizvi SA. Urolithiasis in Sindh: A single centre experience with review of 10,000 cases. J Nephrol Urol Transplant 1998; 1: 10-3.
2. Shoaib M, Zafar Z. Comparison of 24 hours urinary citrate level in urolithiasis patients and healthy controls. J Pak Med Assoc 2005; (55): 371.
3. Wein JA, Kavoussi RL, Nocick CA, Partin WA, Peters CA. Urinary lithiasis. In: Maegaret SP: Campbell Walsh Urology, 9th edition. Saunders, Philadelphia, 2007: 1363-92.
4. Rizvi SA, Naqvi SA, Hussain Z, Hashmi A, Hussain M, Zafar MN et al. The management of stone disease. Br J Urol Int 2002; 89: (Suppl. 1): 62-8.
5. Buchholz NP, Abbas F, Afzal M, Khan R, Rizvi L, Talati J. An ultrasonographic study J Pak Med Assoc 2003; 53(1): 24-5.
6. Stamatelou KK, Francis ME, Jones CA, Nyberg LM, Curhan GC. Time trends in reported prevalence of kidney stones in the United States: 1976-1994. Kidney Int 2003; 63(5): 1817-23.
7. Ahmed E, Khattak AH, Nasrullah, Jan A, Durrani SN. Urinary tract calculi: A four years experience. J Postgrad Med Inst 2006; 20(2): 121-5.
8. Knoll T, Musial A, Trojan L, Ptashnyk T, Michel MS, Alken P, et al. Measurement of renal anatomy for prediction of lower- pole caliceal stone clearance: Reproducibility of different parameters. J Endoural 2003; 17: 447-51.
9. Cass AS, Grine WB, Jenkins JM,Jordan WR, Mobley TB, Myers DA. The incidence of lower pole nephrolithisiasis – increasing or not? Br J Urol 1998; 82(1): 12-5.
10. Rizvi SA, Manzoor K. Causes of chronic renal failure in Pakistan: A single centre experience. Saudi J Kid Dis Transplant 2002; 13: 376-9.
11. Hussain M, Lal M, Ali B, Naqvi SA, Rizvi SA. Management of urinary calculi associated with renal failure. J Pak Med Assoc 1995; 45: 205-8.
12. Nawaz R, Umair UI, Nayyaer UI. Urolithiasis in children in Pakistan. Medical Channel 2007; 13(2): 45-9.
13. Pearle MS, Calhoun EA, Curhan GC. Urologic diseases in America project: urolithiasis. J Urol 2005; 173(3): 848-57.
14. Fong YK, Peh SO, Ho SH, Ng FC, Quek PI, Ng KK. Lower pole ratio: A new and accurate predicator of lower pole stone clearance after shockwave lithotripsy? Int J Urol 2004; 11(9): 700-3.
15. Kelly FX, Banerjee G. Infundibulopelvic angle predicts regrowth of lower calcyeal stones following ESWL. Br J Urol Int 1999; 83: 24.
16. Elbahnasy AM, Shalhav AL, Hoeing DM, Elashry OM, Smith DS, McDouqall EM et al. Lower caliceal stone clearance after shock wave lithotripsy or ureterscopy: The impact of lower pole radiographic anatomy. J Urol 1998; 159(3): 676-82.
17. Filho DA, Favortio LA, Costa WS, Sampio FJB. *Kidney Lower Pole* Pelvicaliceal Anatomy: *Comparative Analysis between* Intravenous urogram and three – Dimensional Helical tomography. J Endourol 2009; 23(10): 1621-25.
18. Albala DM, Assimos DG, Clayman RV, Denstedt JD, Grasso M, Gutierrez-Aceves J et al. Lower pole I: A prospective randomized trial of extracorporeal shock wave lithotripsy and percutaneous nephrostolithotomy for lower pole nephrolithiasis-initial results. J Urol 2001; 166(6): 2072-80.
19. Grases F, Sohnel O, Costa-Bauza A: Renal stone formation and development. Int Urol Nephrol. 1999; 31: 591-600.
20. Zomorrodi A , Buhluli A, Fathi S. Anatomy of collecting system of lower pole of kidney in patients with a single renal stone .A comparative study in individuals with normal kidney .Saudi J Kidney Dis Transpl 2010; 21(4): 666-72.

21. Sampaio FJ, Aragao AH. Inferior pole collecting system anatomy: its probable role in extracorporeal shock wave lithotripsy. J Urol 1992; 147: 322-4.
22. Nabi G.Gupta NP, Mandal S, Hemal AK, Dogra PN, Ansari MS. Is infundibulouretro pelvic angle (IUPA) a significant risk factor in formation of inferior calyceal calculi? Eur Urol 2002; 42: 590-3.
23. Serdar GA, Serkan KA, Tevfik A, Hakan A. Renal anatomical factors for the lower calyceal stone formation. Int Urol Nephrol 2006; 38(1): 79-85.
24. Manikandan R, Gall Z, Gunendran T, Neilson D, Adeyoju A. Do Anatomic Factors Pose a Significant Risk in the Formation of Lower Pole Stones? Urology 2007; 69(4): 620-4.
25. Sumino Y, Mimata H, Tasaki Y, Ohono H, Hoshino T, Nomura T, et al. Predictors of lower pole renal stone clearance after extracorporeal shock wave lithotripsy. J Urol 2002; 168(4): 1344-7.

AUTHOR'S CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

ZS: Conception of idea, Design of study, Acquisition of data

ASK: Acquisition of data

SAP: Analysis and Interpretation of data.

MT: Critical revision of manuscript

MJ: Drafting the manuscript

CONFLICT OF INTEREST

Authors declare no conflict of interest

GRANT SUPPORT AND FINANCIAL DISCLOSURE

NONE DECLARED