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The Impact of Pelvicalyceal System Anatomy on Stone Formation in Patients with Single Lower Pole Calyceal Stone on Computed Tomography Urography

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ABSTRACT

Background: To compare various lower pole pelvicalyceal anatomical factors of stone bearing kidney with contralateral normal kidneys and determine whether these factors predispose to stone formation in one kidney.

Methods: A descriptive study was done with Computed Tomography of 54 patients with solitary lower pole calculus in one kidney and normal contralateral kidney were included. Various lower pole pelvicalyceal anatomical factors like infundibulopelvic angle, infundibular width, infundibular length and calyceopelvic height of both stone bearing and contralateral kidneys were measured and compared for any differences

Results: The mean infundibular width was 5.4±1.9mm on stone bearing kidneys and 5.2±2.05mm on contralateral normal kidneys. The mean infundibular length was 18.9±4.4mm on stone bearing kidneys and 18.8±3.9mm on contralateral normal kidneys. The mean infundibulopelvic angle was 47.9±10.8° on stone bearing kidneys and 47.6±11.2° on contralateral kidneys. The mean calyceopelvic height was 15.7±4.6mm on stone bearing kidneys and 15.5±3.9mm (range 7.5to 23.1mm) on contralateral kidneys. There were no statistically significant differences between stone bearing and contralateral normal kidneys in respect to these pelvicalyceal anatomical factors.

Conclusions: In this study, we found no significant difference in lower pole pelvicalyceal anatomical factors between stone bearing kidneys and contralateral normal kidneys and therefore these factors do not seem to have significant role in stone formation in one kidney compared with the other.

Keywords: Lower pole calculus; pelvicalyceal anatomical factors; urography.

INTRODUCTION

Renal stone disease is a common problem encountered in day-to-day practice.[1] There is high incidence (25-35%) of stone formation in lower pole calyx, however the exact mechanism remains a dilemma.[2,3] Various studies have been conducted to evaluate lower pelvicalyceal anatomical factors to determine whether these play any role in renal stone formation. [4-6] Previous studies have shown that long infundibular length, narrow infundibular width, acute infundibuloureteric angle and higher calyceopelvic height can lead to poor urinary flow in lower calyceal system resulting in urinary stasis and risk of stone formation.[7] Various previous studies have also shown that these anatomical factors are also responsible for poor stone clearance after extracorporeal shock wave lithotripsy (ESWL).[4,5] In this study, we compare various lower pole pelvicalyceal anatomical factors of stone bearing kidney with contralateral normal kidneys and determine whether these factors predispose to stone formation in one kidney.

METHODS

A descriptive study was done with CT urography of 54 patients with solitary lower pole calculus in one kidney and normal contralateral kidney were included in this study, after excluding patients with bilateral nephrolithiasis, multiple renal calculi, hydronephrosis and congenital renal anomalies. Sample size was based upon number of similar cases in the hospital in previous year (n'=62) and study by Cass et al. where prevalence of solitary lower pole calyx stone was 36%.[2]

CT urography was done in department of radiology, BPKIHS between 2nd July 2021 to 1st January 2022. Study was approved by local institutional review committee (IRC). Written consent was taken from the patients for the study. Measurement of various lower pole pelvicalyceal anatomical factors like infundibular width(IW), infundibular length,(IL) infundibulopelvic angle(IPA) and caliceopelvic height (CPH) of bilateral

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kidneys in selected patients was done after three-dimensional (3D) Volume Rendering (VR) and multiplanar reconstruction (MPR) of images. IW was measured at narrowest point along lower pole infundibular axis (Figure 1). IL was measured using Elbahnasy method as distance from distal most point of lower pole calyx with stone to midpoint of lower lip of renal pelvis (Figure 1). IPA was measured using Elbahnasy method by angle between center axis of lower pole infundibulum and ureteropelvic axis (Figure 2). CPH was measured using method by Tuckey et al. which was distance between horizontal line from lowermost point of calyx with stone to highest point of lower lip of renal pelvis (Figure 3). Findings of the study was noted in structured proforma and data analysis was done using SPSS version 28. Paired-t test was applied to show any statistical significance between anatomical measurements of stone bearing and contralateral normal kidney. P value <0.05 was considered statistically significant.

RESULTS

Out of 54 patients, 32 (59.3%) patients were male and 22(40.7%) patients were female with male to female ratio of 1.45:1. Age ranged from 7 to 78 years with mean age of 43.07±15.6 years and most of the patients (15,27.8%) were in age group of 30-39 years. Twenty-seven patients (50%) had stone on left kidney and same number of patients (50%) had stone on right kidney. The mean stone size was 8.05mm (range 2 to 47mm). In our study, most of the stone bearing kidneys (77.7%) had wide infundibulum (□4mm). The mean IW was 5.4±1.9mm (range 2 to 9.6mm) on stone bearing kidneys and 5.2±2.05mm (range 1.6 to 10.4mm) on contralateral normal kidneys and the difference was not statistically significant (p= 0.38). All 54 stone bearing kidneys (100%) had infundibular length less than 3cm. The mean IL was 18.9±4.4mm (range 10.5 to 28.5mm) on stone bearing kidneys and 18.8±3.9mm (range 9.7 to 27.5mm) on contralateral normal kidneys and the mean values between two groups was not statistically significant(p=0.88). In our study, only 46.3% of cases had IPA more acute on stone forming side than the contralateral side. The mean IPA was 47.9±10.8° (range 29.6 to 73°) on stone bearing kidneys and 47.6±11.2° (range 31 to 76°) on contralateral kidneys and the difference between groups was not statistically significant(p=0.77). Similarly, 53.7% of cases with stone bearing kidneys had CPH more than 15mm.The mean CPH was 15.7±4.6mm (range 6.7 to 28mm) on stone bearing kidneys and 15.5±3.9mm (range 7.5to 23.1mm) on contralateral kidneys and the findings were not statistically significant between two groups (p=0.38). Overall, there were no statistically significant differences between stone bearing and contralateral normal kidneys in respect to IW, IL, IPA and CPH.

Table 1. Comparison of lower pole pelvicalyceal anatomical parameters between stone-bearing and contralateral kidneys.

Parameter	Stone bearing kidney (mean±SD)	Contralateral normal kidney (mean±SD)	P value
Infundibular width	5.4±1.9mm	5.2±2.05mm	0.38
Infundibular length	18.9±4.4mm	18.8±3.9mm	0.88
Infundibulopelvic angle	47.9±10.8°	47.6±11.2°	0.77
Caliceopelvic height	15.7±4.6mm	15.5±3.9mm	0.38

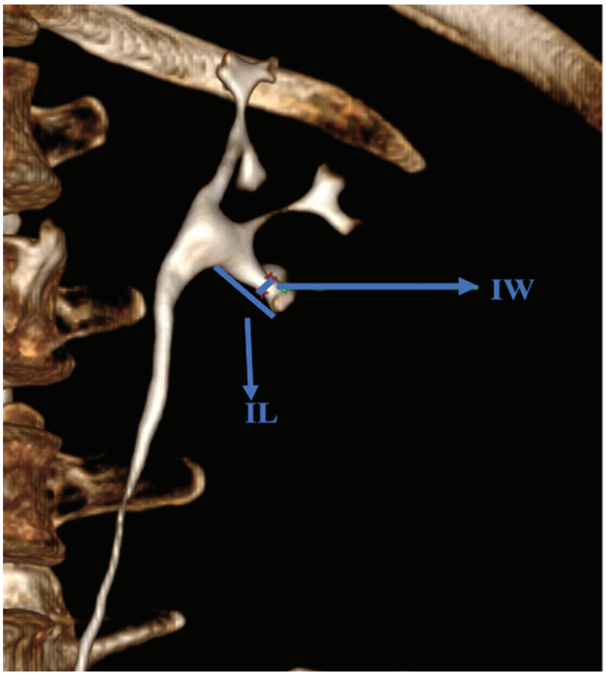

Figure 1. 3D Volume Rendered CT urography Image showing measurement of Infundibular width (IW) and Infundibular length (IL).

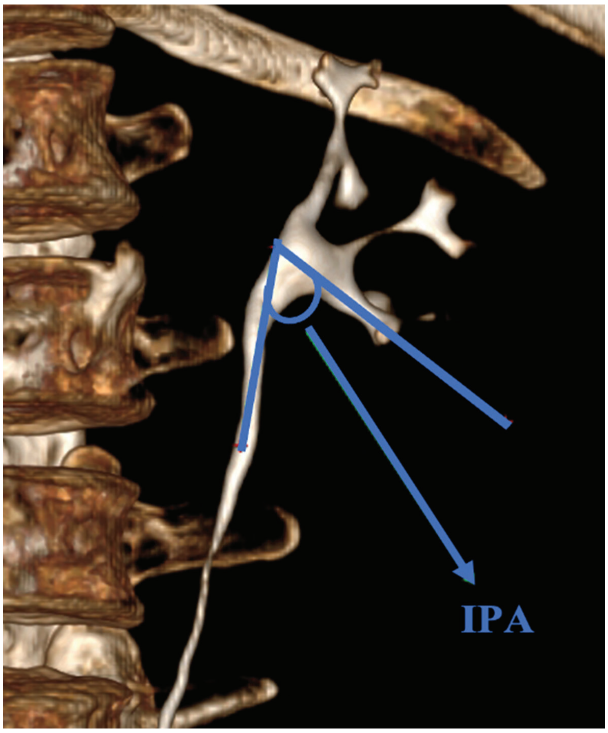

Figure 2. 3D Volume Rendered CT urography Image showing measurement of Infundibulopelvic angle (IPA) using Elbahnasy method.

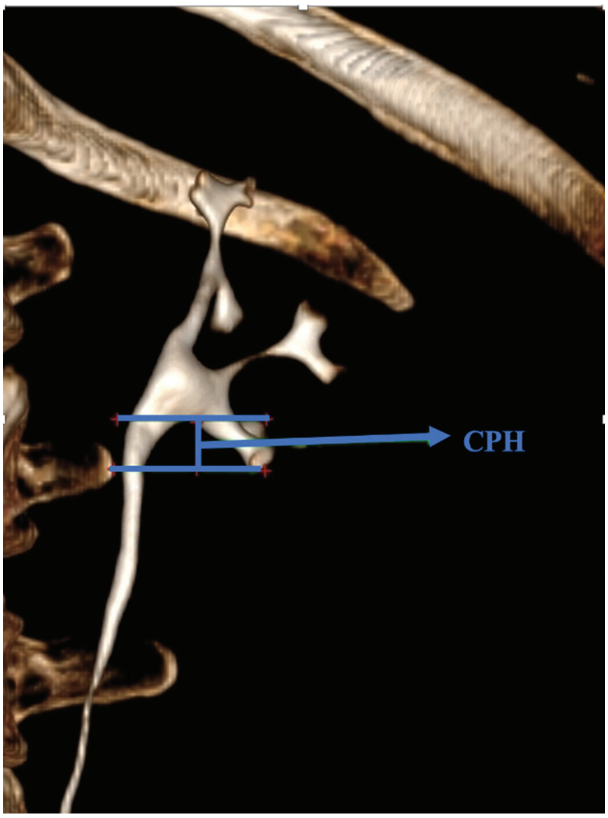

Figure 3. 3D Volume Rendered CT urography Image showing measurement of Caliceopelvic height (CPH).

DISCUSSION

Renal stone is a common occurrence worldwide and various risk factors have been described regarding formation of renal stones. Likewise, there is high incidence (25-35%) of solitary stone formation in lower pole calyx of single kidney which raises a doubt that there might be some anatomical factors that influence the stone formation in lower pole calyx of kidney.[2] Several studies have been conducted to determine the role of various pelvicalyceal anatomical factors on stone formation in lower pole calyx of unilateral kidney. The initial landmark study about these factors was done by Sampaio et al. in 1992 in which they found that narrow infundibulopelvic angle (<90°), multiple calices (>3) and narrow infundibular width(<4mm) of lower pole pelvicalyceal system can inhibit the clearance of stone from lower pole calyx following ESWL.[6] Similar findings were also observed in a study by Elbahnasy et al. in 1998 where they found that narrow infundibular width (<5mm), infundibulopelvic angle <90° and long infundibular length (>3cm) are unfavorable factors for stone clearance from lower pole calyx after ESWL.[5] Similarly, these factors might also be risk factors for initial formation of stone in lower calyx due to urinary stasis and unfavorable gravity effect.[8] In our study, we measured different lower pole pelvicalyceal anatomical factors like infundibular width, infundibulopelvic angle, infundibular length and caliceopelvic height on CT urography and find out any significant difference of these factors between both stone bearing and contralateral normal kidneys

Previous studies have shown that narrow IW can cause urinary stagnation and hinder stone passage from inferior calyceal system.[5,9] However Gokalp et al. found lower infundibular diameter (LID) to be higher in stone formers (mean 9.98mm) and concluded LID to be a risk factor for stone formation.[10] Majority of stone bearing kidneys (77.7%) had wide infundibulum (□4mm) in our study. We found mean IW was slightly wider (5.4mm) on stone bearing kidneys compared to contralateral normal kidneys (5.2mm) however the difference was not statistically significant (p=0.38). Our findings were similar to study by Nabi et al. and Balawender et al. where they found mean IW of stone bearing kidneys was wider (5.6mm and 4.2mm respectively) compared to contralateral kidneys (4.8mm and 3.7mm respectively).[11,12] However, they also did not find statistically significant difference between infundibular width of both sides. In contrast to our study, in a study by Shah et al., they found that mean IW of stone bearing kidney was much narrower (3.1mm) compared to contralateral normal kidney (6.8mm) with significant p value of <0.001 and concluded that narrow IW is a risk factor for stone formation in lower pole calyx.[13]

Infundibular length (>3cm) is another of the unfavorable factors for stone clearance from lower pole calyx after ESWL.[5] Long IL can cause urinary stasis and impairment of calyceal drainage, therefore can be considered another possible risk factor for stone formation.[8] All 54 cases (100%) with stone bearing kidneys in our study had short infundibular length (<3cm). In our study, mean IL was almost similar (18.9mm) on stone bearing kidneys compared to contralateral normal kidneys (18.8mm) with no statistically significant difference of IL between two groups (p=0.88). Our findings were similar to study by Balawender et al. where they found mean IL of stone bearing kidney (15.3mm) was similar to contralateral kidney (14.6mm) and there was no statistically significant difference (p=0.32) between the two sides.[12] However, in a study by Shah et al., they found mean IL of stone bearing kidneys(32.1mm) was longer than normal contralateral side (27.3mm) and the difference was statistically significant (p<0.001) and they concluded that long IL can be considered a risk factor for renal stone formation.[13]

Both Elbahnasy and Sampaio et al. in their study found that narrow infundibulopelvic angle (<90°) inhibit the clearance of stone from lower pole calyx following ESWL.[5,6] In a study by Gozen et al., acute IPA was considered a risk factor for stone formation in which they believe that this condition can cause stagnation and retention of crystals in inferior calyceal system.[8] Nabi et al. and Gozen et al., in their studies found that inferior infundibuloureteric pelvic angle (IUPA) was more acute on stone forming side in majority of cases (74% and 72% respectively).[11,8] However we found only 46.3% of cases IPA was more acute on stone forming side than the non-stone forming side. In our study mean IPA measured using Elbahnasy method was similar on stone bearing kidneys (47.9°) compared to contralateral normal kidneys (47.7°) and there was no statistically significant difference between two sides(p=0.77). Similar findings were noted in study by Balawender et al where they found mean IPA of stone bearing kidneys (59.50) by Elbahnasy method was similar to contralateral normal kidneys (59.7) with insignificant p value (p=0.465).[12] In contrast, in the study by Shah et al., mean IPA of stone bearing kidney was more acute (53.2°) than contralateral side (60.2°) and the difference was statistically significant(p<0.002).[13] Similarly in a study by Nabi et al., mean IPA was 47° on affected side compared with 56° on unaffected side and the findings were significantly different between two sides and they concluded that IUPA was a significant factor for stone formation.[11]

According to Tuckey et al., CPH is also one of the risk factors affecting the post ESWL stone clearance. In their study, they found only 52% of patients were stone free after ESWL with CPH >15mm.[4] However other studies reported that CPH does not have any role in lower pole stone formation or stone clearance.[9,14] In our study, 53.7% of cases with stone bearing kidneys had CPH >15mm. However, mean CPH on stone bearing kidneys (15.7mm) and contralateral kidneys (15.5mm) were similar and the findings were statistically not significant (p=0.38). Similar finding was noted in study by Balawender et al and Manikandan et al., where they found mean CPH of stone bearing kidney (10.99 mm and 21.6mm respectively) and contralateral kidney (10.44mm and 22.6mm respectively) were similar and the findings were statistically not significant (p=0.68 and p=0.3) and therefore do not play any role in stone formation in lower pole calyx.[12,15]

There are few limitations to our study. It is possible that contralateral non stone bearing kidney which is considered normal in present study may develop calculus in the future. So, comparison of anatomical parameters of stone bearing kidney with truly normal kidney without stone might not have been done ideally. Histological confirmation of the calyceal anatomy was not done. Static measurements done in our study are not as reliable as dynamic study of pelvicalyceal system.

CONCLUSIONS

In this study, we found no significant difference in lower pole pelvicalyceal anatomical factors between stone bearing kidney and contralateral normal kidneys and therefore these factors do not seem to have significant role in stone formation in one kidney compared with the other.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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