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The impact of pelvicalyceal anatomy on the stone formation in patients with lower pole renal stones

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Background: *The aim of our study was to determine whether various anatomic factors constitute a predisposition to a lower pole renal stones.*
Materials and methods: *We analysed the computed tomography (CT) urography of 75 patients with a single lower pole stone. Measurements were taken of the infundibulopelvic angle (IPA), infundibular width (IW), infundibular length (IL) and calyceopelvic height (CPH).*
Results: *The mean patient age was 50 years (range 17–79 years). The mean stone size was 11.9 mm. The mean IPA using Sampaio method in affected kidney was 113.4 ± 15.3º (range 80–139º), 59.5 ± 17.3º using Elbahnasy method. The values of IPA on the contralateral kidney were 119.86 ± 15.37º (range 79–141°; p = = 0.001) using Sampaio method of measurement and 59.78 ± 12º (range 34–90°; p = 0.465) using the method described by Elbahnasy. We reported statistically significant differences between stone-bearing kidney and contralateral kidney in measurement IPA using only Sampaio method. The mean infundibular width was 4.22 ± 1.81 mm on the affected kidney and 3.72 ± 2.5 mm on the contralateral side (p = 0.164). The mean infundibular length was 15.37 ± 4.57 mm on the affected kidney and 14.66 ± 4.35 mm on the unaffected side (p = 0.329). The CPH was 10.19 ± 4.05 mm on the affected kidney and 10.44 ± 3.83 mm on the normal side (p = 0.688).*
Conclusions: *Pelvicalyceal morphology of the kidney is one of the factors that determine the risk of developing kidney stones. Out of the analysed morphological parameters of kidney IPA is a statistically significant risk factor to form lower pole kidney stones. Other anatomic parameters did not seem to have a significant role in predisposing to form lower pole kidney stone.* (Folia Morphol 2018; 77, 1: 16–21)

Key words: anatomy of lower calyx, urolithiasis, extracorporeal shock wave lithotripsy (ESWL) procedure

INTRODUCTION

Nephrolithiasis is a common disorder. It is estimated that approximately 10% of population of developed countries will develop urinary concrements throughout their life [23]. Detection of a first stone is associated with 25% risk of development of another stone in the next decade. In case of patients with primary multiple nephrolithiasis (two or more detected concrements) the risk rises to 75% [1]. Aetiology of the condition is

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multi-factorial. Nephrolithiasis is an effect of environmental conditions, dietary behaviour as well as coexisting metabolic disorders, genetic factors and anatomical structure of the renal collective system. Because of anatomical conditions, and despite the constant development of endourology, calculosis of the inferior calyx constitutes a serious therapeutic problem. The anatomical structure of the inferior calyx is a significant factor hindering elimination of residue stones post the extracorporeal shock wave lithotripsy (ESWL) procedure. Morphometric conditions of the inferior calyx constitute also an important limitation for efficacy of retrograde intra renal surgery (RIRS) procedures within the inferior calyx. The most extensively studied anatomic factors of the lower pole kidney have been the infundibulopelvic angle (IPA), infundibular width (IW), infundibular length (IL) and calyceopelvic height (CPH).

MATERIALS AND METHODS

We retrospectively reviewed the computed tomography urography of 75 patients (42 male and 33 female) presenting with a single lower pole kidney stone. The mean patient age was 50 years (range 17–79). The mean stone size was 11.9 mm. The clinical data of the patients (between January 2016 and December 2016) were obtained from a database kept in the Department of Urology, Pope John Paul II Regional Hospital in Zamosc. For the present study, approval was obtained from the Ethical Committee of our institution. Exclusion criteria of the study included multiple stones, bilateral stones and renal anomalies. The anatomic measurements were taken on the affected side and compared with the contralateral kidney.z We measured IPA using Sampaio method [18] and Elbahnasy method [6]. IPA using Sampaio method measured by angle made between lateral border of renal pelvis and lower border of lower pole infundibulum (Fig. 1). IPA using Elbahnasy method was measured by angle made between line through central axis of lower infundibulum and ureteropelvic axis (Fig. 2). IW was defined as narrowest point along lower pole infundibular axis, IL using Elbahnasy method measured by distance from most distal point at bottom of calyx containing stone to midpoint of lower lip of renal pelvis (Fig. 3) [6]. CPH was based on Tuckey et al. [24] method measured by distance between horizontal lines from lowermost point of

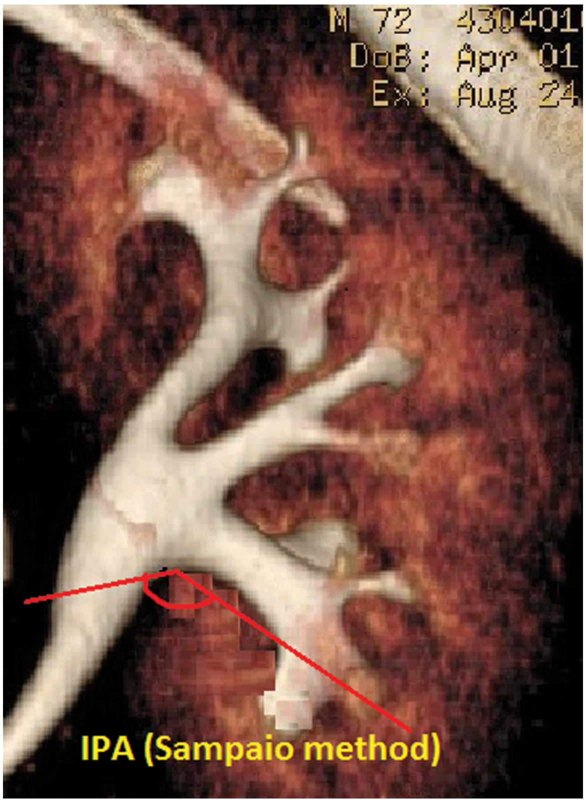

Figure 1. Infundibulopelvic angle (IPA) measured Sampaio method.

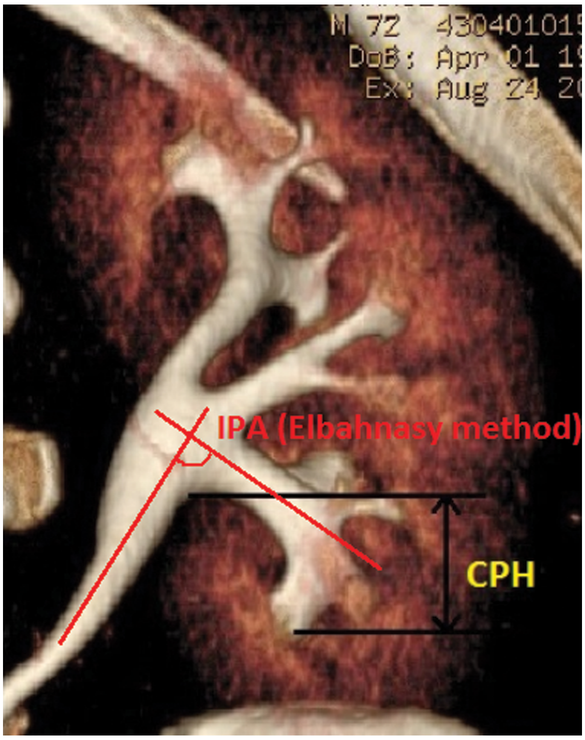

Figure 2. Infundibulopelvic angle (IPA) measured Elbahnasy method; CPH — calyceopelvic height.

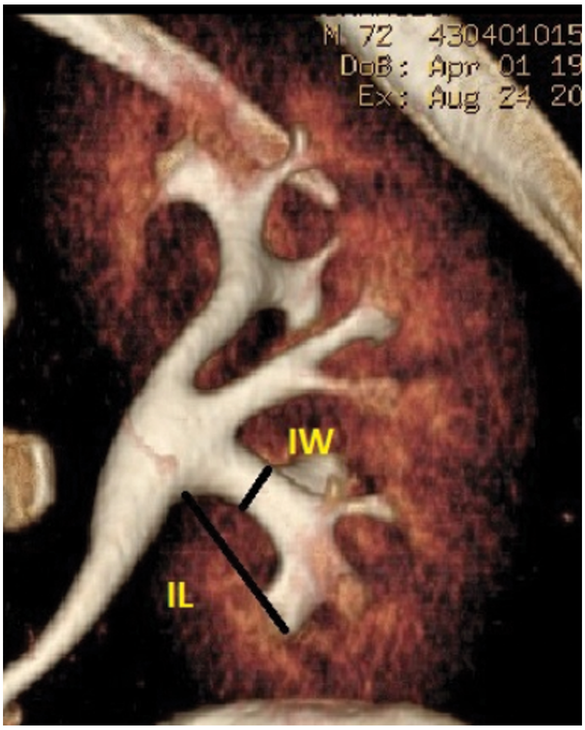

Figure 3. Infundibular width (IW) and infundibular length (IL) measured.

calyx containing stone to highest point of lower lip of renal pelvis (Fig. 2). In statistical analysis the normality was tasted with Shapiro-Wilk test. For normally distributed date Student's t-test was used. The level of significances used was set at $p < 0.05$.

RESULTS

The mean IPA using Sampaio method in affected kidney was 113.4° ± 15.3° (range 80° to 139°), 59.5° ± 17.3° using Elbahnasy method. The values of IPA on the contralateral kidney were 119.86° ± 15.37° (range 79°–141°; $p = 0.001$) using Sampaio method of measurement and 59.78° ± 12° (range 34°–90°; $p = 0.465$) using the method described by Elbahnasy. We reported statistically significant differences between stone-bearing kidney and contralateral kidney in measurement IPA using only Sampaio method. The mean IW was 4.22 ± 1.81 mm on the affected kidney and 3.72 ± 2.5 mm on the contralateral side ($p = 0.164$). The mean IL was 15.37 ± 4.57 mm on the affected kidney and 14.66 ± 4.35 mm on the unaffected side ($p = 0.329$). The CPH was 10.19 ± ± 4.05 mm on the affected kidney and 10.44 ± ± 3.83 mm on the normal side ($p = 0.688$) (Table 1).

DISCUSSION

The anatomical structure of the renal collective system is one of factors playing an important role in pathogenesis of nephrolithiasis, and is of crucial importance for planning of surgical treatment of the condition. Knowledge of morphology of the inferior calyx is particularly important, as constitutes a basis for selection of appropriate method of lithotripsy of stones localised there. ESWL and endourological surgery constitute the standard of care for inferior calyx calculosis. Considering a significant limitation of ESWL efficacy in relation to concrements in the inferior calyx (stone free rate of ESWL for lower pole calculi is 25–85%) [4], the procedure is replaced by endoscopic procedures, and the European Association of Urology guidelines recommend application of endourological surgical procedures to treatment of concrements in the inferior calyx. RIRS has lately became a standard in treatment of lower pole calculi, particularly in patients demonstrating an unfavourable anatomy of the calyceal system, in whom ESWL offers a greatly limited efficacy [3, 4]. Among factors favouring formation of concrements and limiting efficacy of lithotripsy within the inferior calyx, there are the following anatomical conditions of the lower pole — steep IPA, long IL > 10 mm, and IW < 5 mm

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

Variable	Stone-bearing kidney (mean ± SD)	Contralateral kidney (mean ± SD)	P
IPA Sampaio [°]	113.4 ± 15.3	119.86 ± 15.37	0.001
IPA Elbahnasy [°]	59.5 ± 17.3	59.78 ± 12	0.465
Infundibular length [mm]	15.37 ± 4.57	14.66 ± 4.35	0.329
Infundibular width [mm]	4.22 ± 1.81	3.72 ± 2.5	0.164
Calyceopelvic height [mm]	10.19 ± 4.05	10.44 ± 3.83	0.688

IPA — infundibulopelvic angle; SD — standard deviation

[14, 15, 20]. Sampaio et al. [18, 19] first described the impact of the lower pole anatomy on post-ESWL stone clearance and suggested that lower pole IPA below 90° decreased the stone-free rate post the ESWL. They found that 75% of patients with the IPA of over 90° were stone-free compared to 23% in case of those with the IPA below 90°. Keeley et al. [9] demonstrated a 34% clearance when IPA was less than 100°. In our study, IPA < 90° measured using the Sampaio method in stone-containing kidneys was found in 12% (9/75) patients, and in the contralateral, stone-free kidney, in 6.7% (5/75). In the study IPA was measured using both Sampaio and Elbahnasy method. According to Sampaio, IPA is defined as the angle between the lateral border of kidney pelvis and the lower border of infundibulum of the inferior calyx [18]. Elbahnasy's method defines the same value as the angle between the line drawn through the central axis of the lower infundibulum and the vertical ureteropelvic axis [6]. We reported existence of statistically significant differences between stone-bearing kidney and the contralateral kidney in the measurement of IPA using only the Sampaio method — the mean IPA on the affected kidney was 113.4°. Corresponding values measured in the normal kidney was 119.8° ($p = 0.014$), although mean values in both kidneys exceeded 90º. Other investigators have also studied IPA that could potentially affect clearance of lower pole stones treated with the ESWL [5, 6] and the RIRS [16]. Ruggera et al. [17] evaluated 107 patients treated for solitary lower pole kidney stone with the ESWL. In their study only 58% of cases became stone-free, while 42% retained some residual stone fragments. Özgör et al. [13] evaluated efficacy of ESWL procedures in a paediatric population, using Sampaio's and Elbahansy's methods for the IPA measurement. They set the cut-off point at 40° for the Elbahansy's method, and 90° for the Sampaio's method. In that study, 5% of patients were stone-free with IPA < 90° according to the Sampaio's method, and the corresponding value for the Elbahansy's method was 6% [13]. The definition of IPA has a tendency to vary, with at least four different methods of measurement described [11]. Some investigators found that the IPA was significantly correlated with the stone-free rate [6, 11, 18], others did not [2, 21]. Nabi et al. [12] analysed 100 patients with lower calyceal stones and found that lower pole IPA was more acute in 74% of cases in the stone-bearing kidney than in the normal, contralateral one. In that study IPA constituted a statistically significant risk factor for lower incidence of calyceal stones [12]. Kupeli et al. [10] in their analysis of the effect of morphological structure of the inferior calyx on development of nephrolithiasis demonstrated absence of any significant correlations between the IPA of the lower pole and formation of stones. Besides morphology of the inferior calyx, structure of the whole renal collective system was analysed in that study. Statistically significant differences were demonstrated only for the middle calyceal IPA [10]. Similarly, Gurocak et al. [8] compared 119 lower calyceal stone-forming kidneys and concluded that lower pole IPA was not an important factor for stone formation in the lower calyx. In this study authors compared anatomical parameters of the stone-forming kidney with those in healthy control kidneys, and for that reason analysed kidneys were not in a similar metabolic condition [1].

Other anatomical factors analysed in our study were: IW and IL. According to Sampaio et al. [18] 60% of kidneys demonstrating a regular structure of the renal collective system has the infundibular width > 4 mm. In our study stone-bearing lower pole IW > 4 mm affected 62% of patients, although in contralateral kidney lower pole IW > 4 mm affected 44% of patients. In our study none of the infundibular factors were significantly different between the affected and unaffected kidney. Kupeli et al. [10] reported statistically significant differences in lower calyceal IW ($p = 0.001$) between the stone-bearing kidney and the contralateral kidney, although there were no differences in lower calyceal IL ($p = 0.568$). Similarly to IPA, IW is a significant factor affecting the post-ESWL stone-free. Elbahnasy et al. [6] found that 60% of patients with the IW of more than 5 mm were stone-free after ESWL, compared to 33% with IW below 5 mm. Mean IL values were 15.3 mm in the stone-bearing kidney and 14.6 mm in the contralateral one. The study demonstrated no significant differences between IL values and no value over 30 mm was observed in any of measurements. According to Elbahnasy et al. [6], IL > 30 mm decreased stone clearance. Several published reports used the infundibular length-to-width ratio [7, 22]. Sumino et al. [22] found that the lower infundibular length-to-width was the strongest prognostic factor of stone clearance after the shock wave lithotripsy. In their study, the stone-free rate for a lower infundibular length-to-width rate of less than 7 was 72%, whereas the stone-free rate was 33% for the ratio of

7 or greater. Similar correlations were reported by Fong et al. [7], but the length-to-width rate cut-off point was less than 3.5.

Calyceopelvic height was the last analysed anatomical factor. According to Tuckey et al. [24], CPH constitutes yet another factor affecting the post-ESWL stone clearance. Authors reported that 92% of patients with CPH of less than 15 mm were stone-free after the ESWL, in contrast to 52% of stone-free among those with the CPH of 15 mm or greater [24]. In this study the CPH over 15 mm in the stone-bearing kidney was observed in 16% of patients, and the ratio was 6.6% for the contralateral kidney. However, some authors reported that CPH did not have an effect on lower pole stone formation and the success of ESWL in those patients [21, 22].

CONCLUSIONS

The aetiology of stone formation is multifactorial in nature. Pelvicalyceal morphology of the kidney is one of factors that possibly determine the risk of developing kidney stones. Among the analysed morphological parameters of the kidney in our study, IPA was a statistically significant risk factor of lower pole kidney stones. However, lack of a unified definition of IPA limits value of that parameter in the assessment of risk of inferior calyceal stones. What is more IPA as a significant risk factor was only determined by one statistical method and it needs further research to confirmation. Other anatomic parameters in our study did not seem to have a significant role in predisposition to lower pole kidney stones.

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