# The Association of a Number of Anatomical Factors with the Success of Retrograde Intrarenal Surgery in Lower Calyceal Stones"

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**Purpose:** To determine anatomical factors affecting Retrograde Intrarenal Surgery (RIRS) success in the treatment of renal lower calyx stones.

**Materials and methods:** The results of patients were evaluated retrospectively. The patients who have preoperative intravenous urography (IVU) and computed tomography (CT) were divided into two groups as successful (S)(N=103) and unsuccessful(U) (N=29). The anatomic characteristics such as infundibulopelvic angle (IPA), infundibular length (IL), infundibular width (IW) and pelvicaliceal height (PCH) values were compared among two groups.

**Results:** Mean patient age was 47±13.6 years in group S and 49.5 ±11.9 years in group U. The mean stone size was 10mm (6-54mm) in group S and 19mm (8-45mm) in group U ($P < .001$) Mean IPA was 85.8 ±16.9 degree in group S versus 54.7 ± 11.5 degree in group U. The mean PCH was 1.9cm (0.5-4cm) in group S versus 2.3cm (0.7-3.9cm) in group U. The mean IL were 2.7 ± 0.8 cm and 3.2±0.7cm in group S and group U, respectively. The mean IWs were 0.7 cm (0.2-2.3cm) and 0.7cm (0.3-2) in group S and group U, respectively. The differences were statistically significant for IPA, PCH, IL ($P < .05$) while was not statistically significant for IW ($P > .05$). After multivariate analyses, PCH, IPA and stone size were statistically significant factors.

**Conclusion:** In our study we found that IPA, PCH and stone size were significant anatomical factors affecting RIRS success in the treatment of renal lower calyx stones.
The patients whose IPA, PCH and stone size valuables are unsuitable, may need multiple RIRS sessions or additional treatment modalities.

**Keywords:** anatomy; lower calyx; retrograde intrarenal surgery; stone; success.

## INTRODUCTION

Urinary stone disease affects human health to a great degree. Today, retrograde intrarenal surgery (RIRS) is used more and more due to its high success in kidney stone treatment and low complication rates.[(1)] The probability of failure is higher for the stones in lower renal calices.[(2)] Predicting the failure especially in lower calyx stones can prevent unnecessary interventions. Studies investigating the factors that predict this failure were carried out. The number of patients who have lower calyx stones is low in these studies. In this retrospective study, we aimed to determine the anatomical factors that predict this failure by comparing the data of the patients who underwent successful and unsuccessful RIRS procedures , which were performed for the treatment of the stones in the lower renal calices.

## MATERIALS AND METHODS

In this study, 1035 patients who had undergone RIRS due to kidney stone at our urology clinic were analysed retrospectively upon receiving the local ethics board approval between February 2012 and November 2014. Among cases with isolated lower calyx stone, 132 patients who had intravenous uroghraphy (IVU) and computerized tomography(CT)and undergone successful (103 patients) or unsuccessful (29 patients) RIRS procedure were included in the study. Only patients whose stones were treated in lower calyx were included our study. Patients with ureteropelvic junction obstruction, horseshoe kidney, ureteral stricture, preoperative hydronephrosis and multiple caliceal stones were excluded. Among the cases that underwent unsuccessful RIRS, failure due to ureteral perforation, urethra or ureteral stricture, ureteropelvic junction obstruction and parenchyma stone were excluded from the study.
Complete blood count, serum biochemical values, bleeding and coagulation profile, urine analysis, urine cultures of all patients were evaluated. For radiopaque stones, the longest diameter in X-ray of kidney ureter bladder (X-ray KUB), and for non-opaque stones, the longest diameter in ultrasound were measured to calculate the size of the stones. In multiple stones, the longest diameter of each stone was measured and the sum of all measurements was defined as the size of stone. Informed consent was taken from all patients before the

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**Table 1.** Demographic and clinical features of groups S and U.

| Variables | Successful (N=103) | Unsuccessful (N=29) | *p*-value |
|---|---|---|---|
| Age (year) (mean±SD) | 47.0 ± 13.6 | 49.5 ± 11.9 | 0.381 |
| Gender N(%) | 0.118 | | |
| Male | 58 (56.3%) | 21 (72,4%) | |
| Female | 45 (43.7%) | 8 (27.6%) | |
| Weight (kg) (mean±SD) | 73.8 ± 8.5 | 75.0±7.9 | 0.479 |
| Height (cm) (mean±SD) | 169.5 ± 64 | 171.4 ± 5.9 | 0.149 |
| BMI (kg/m2) (mean±SD) | 25.7 ± 2.8 | 25.5 ± 2.8 | 0.815 |
| ASA N(%) | | | 0.814 |
| I | 16 (15.5%) | 5 (17.2%) | |
| II | 76 (73.8%) | 22 (75.9%) | |
| III | 11 (10.7%) | 2 (6.9%) | |

**Abbreviations:** BMI, Body Mass Index; ASA, American Society of Anesthesiologists

operation. Parenteral antibiotic was administered to all patients 1 hour before the operation.

Following general anaesthesia in supine position, the position of the patient was changed to modified dorsal lithotomy. Later, semirigid ureterorenoscopy was performed and guide wire was inserted into the ureter under fluoroscopic control. Following the first guide wire, ureter was approached with semirigid ureterorenoscopy and diagnostic ureterorenoscopy was performed which also dilated the ureter. In the event that it was not possible to pass from ureteral orifice, the operation was performed two weeks after passive dilatation upon placing JJ stent. Later on, ureteral access sheath was inserted into upper ureter under fluoroscopic control over the guide wire. Lithotripsy was performed with 200micron holmium laser probe (Ho: Yttrium Aluminum Garnet(YAG) Laser; DornierMedTech; Munich, Germany) after monitoring the stone with flexible ureterorenoscopy (Flex-X2, Karl Storz, Tutlingen, Germany). The stone basketing was used by a manual pump or tipless nitinol baskets (Zero Tip™; Boston Scientific Microvasive) . During the operation, the following settings were used for the laser energy: 8-10 Hertz frequency and a power of 1200-1500 Joule . Fragmentation and dusting were used for stone management.

Intraoperative fluoroscopic control and monitoring all calyces with flexible ureterorenoscopy were performed to control the clearance of stones at the end of the operation when the stones were fragmented. After the procedure, JJ stent was placed in the patients. 16Fr Foley urethral catheter was inserted following the procedure. Success was evaluated with X-ray for opaque stones and ultrasound for non-opaque stones 24 hours after the operation in addition to intraoperative control.

The procedure was interpreted as successful in patients in whom all the stones were removed. On the 1st postoperative day, urethral catheter was removed. In case when additional procedure was not planned, JJ stent of the patient was removed 3 weeks later. Patients were followed for six months.

All patients have preoperative IVU and CT. But for determining anatomical factors we made the measurements in IVU . Some variables such as infundibulopelvic angle(IPA), infundibular length(IL), infundibular width(IW) and pelvicaliceal height (PCH) were measured on IVU of the patients. (**Figure 1**)

IPA is the angle formed when the axis that passes through lower calyx and the axis that passes through ureteropelvic junction intersect,

PCH is the distance to the horizontal axis drawn from the middle point of pelvis and from the lowest point of lower calyx

IL is the axis that extends from lower calyx infundibulum to pelvis,

IW is the narrowest infundibulum diameter in lower calyx.

### *Statistical Analysis*

The data was analysed with SPSS 11.5 for Windows Statistical Software Package. For the significance of the intergroup mean values, Student's t test, and for the significance of the median value difference, Mann Whitney U test were used. Categorical variables were examined with Pearson Chi-Square, Fisher's exact or Probability Ratio test.

In distinguishing whether or not clinical measurements such as IPA, IL, IW, PCH and stone size were determinant for procedure success we calculated the area below the ROC curve and 95% reliability interval. The most important determining factor(s) in differentiating the group in which the procedure was performed successfully and unsuccessfully was (were) investigated with Multivariate Retrospective Stepwise Elimination Logistic Regression Analysis. According to Hosmer and Lemeshow, variables with $P < .25$ in univariate statistical analyses that might be considering significant in multivariate analyses were included in multivariate regression model. According to this information, the variables with $P < .25$ in univariate analyses were included in logistic regression model as potential risk factors. In the next step using Backward LR method, the most specific factors, were used to distinguish the groups from each other. All the variables found with $P < .25$ in univariate statistical analyses were included in the multivariate model as potential risk factors. The

**Table 2.** Other clinical features of groups S and U.

| Variables | Successful (n=103) | Unsuccessful (n=29) | *p*-value |
|---|---|---|---|
| Stone pole N(%) | | | 0.182 |
| Left | 48 (46.6%) | 18 (62.1%) | |
| Right | 54 (52,4%) | 10 (34,5%) | |
| Bilateral | 1 (1.0%) | 1 (3,4%) | |
| Number of the stones (min-max.) | 1 (1-3) | 2 (1-4) | < 0.001 |
| Multiple stone N(%) | 24 (23.3%) | 17 (58.6%) | < 0.001 |
| Stone size (mm.)(min.-max.) | 10 (6-54) | 19 (8-45) | < 0.001 |
| Access sheath usage | 83 (80.6%) | 27 (93.1%) | 0.159 |
| Operation time(min.)(min.-max.) | 45 (15-80) | 45 (30-80) | 0.203 |
| DJS usage n(%) | 78 (75.7%) | 22 (75.9%) | 0.988 |
| Hospital stay (min.-max.) | 1 (1-1) | 1 (1-1) | - |
| Residual Stone size (min.-max.) | - | 10 (5-24) | - |
| SBP(mmHg) (mean±SD) | 128.4 ± 7,5 | 127.9 ± 7,4 | 0,766 |
| DBP(mmHg) (mean±SD) | 81.3 ± 4,4 | 80,2 ± 5,1 | 0,239 |
| SpO2(mean±SD) | 98.3 ± 1.1 | 98,5 ± 0,7 | 0,498 |
| SWL N(%) | 23 (22.3%) | 13 (44,8%) | 0,016 |
| Secondary N(%) | 15 (14.6%) | 10 (34,5%) | 0,016 |
| Opaque N(%) | 68 (66.7%) | 26 (89,7%) | 0,015 |
| Result N(%) | | | - |
| Follow-up | 103 (100,0%) | 16 (55,2%) | |
| PCNL | - | 7 (24,1%) | |
| RIRS | - | 6 (20,7%) | |

**Abbreviations:** DJS, Double J Stent; min,minimum; max,maximum; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; SWL, Shock Wave Lithotripsy; PCNL, Percutaneous Nephrolithotomy; RIRS, Retrograde Intrarenal Surgery.

odds rate of each variable, 95% confidence interval and wald statistics were calculated.

Results were accepted as statistically significant for $P < .05$.

## RESULTS

The mean age were 47(±13.6) years in group S and 49.5(± 11.9) years in group U. Comparing the patient ages, no statistically significant difference was found between group S and U ($P = .35$).

When patient groups were compared with regard to demographic features, no statistical significant difference was observed in terms of gender, body weight, height, body mass index ( BMI) (kg/m$^2$), American Society of Anesthesiologists (ASA) scores (**Table 1**).

When the intergroup clinical findings were examined, no statistically significant difference was observed in terms of the side of the stone (right/left) access sheath usage, operation time, JJ stent usage, hospital stay (**Table 2**).

When the other clinical findings were examined, while no statistically significant difference was observed in systolic blood pressure (SBP), diastolic blood pres-

**Table 3.** Anatomical features of inferior calyx in groups S and U.

| Variables | Successful (n=103) | Unsuccessful (n=29) | *p*-value |
|---|---|---|---|
| IPA (deg.)( mean±SD) | 85,8 ± 16,9 | 54,7 ± 11,5 | < 0.001 |
| IL (cm.) (mean±SD) | 2,7 ± 0,8 | 3,2 ± 0,7 | 0.004 |
| IW (cm.) (min.-max.) | 0,7 (0,2-2,3) | 0,7 (0,3-2,0) | 0.139 |
| PCH (cm.) (min.-max.) | 1,9 (0,5-4,4) | 2,3 (0,7-3,9) | 0.007 |

**Abbreviations:** IPA, Infundibulopelvic Angle; IL, Infundibular Length; IW, Infundibular Width; PCH, Pelvicaliceal Height; min, minimum; max, maximum

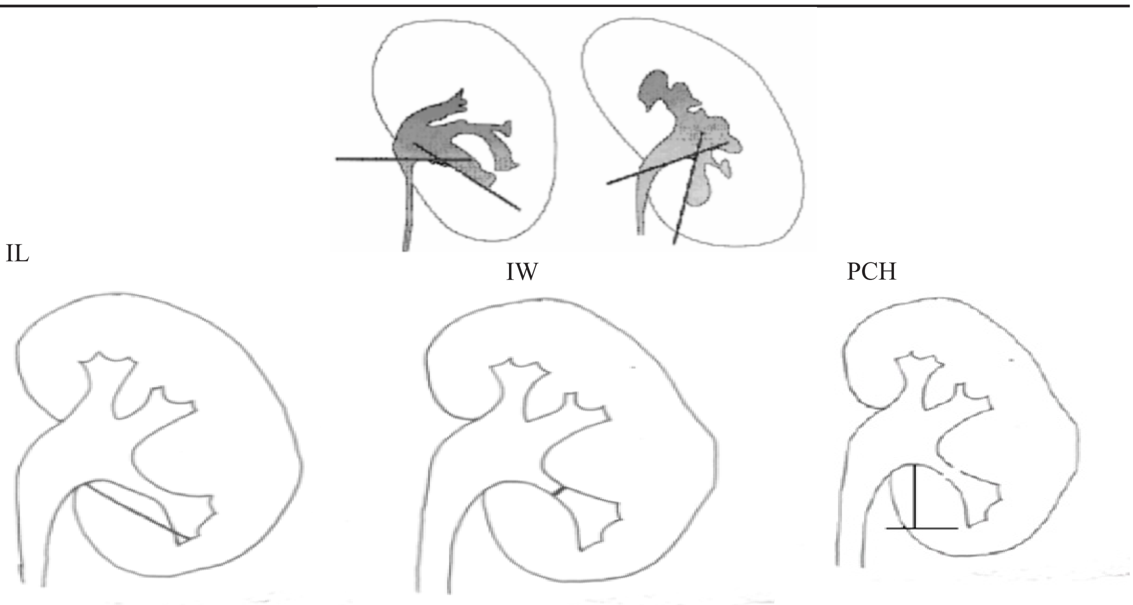


**Figure 1.** IPA, IL, IW, PCH measurement images
IPA

sure (DBP), oxygen saturation ($SpO_2$) between the groups, statistical significant difference was found in shock wave lithotripsy (SWL) history, being opaque/non-opaque, being secondary (that is to say that patient underwent a surgery before). While 16 patients were followed in the group U, percutaneous nephrolithotomy (PNL) procedure was performed for 7 patients, and RIRS was performed on 6 patients (**Table 2**). The patients who had undergone second PNL and RIRS were stone free after the second procedure.

When the other variables were examined, while significant difference was observed in IPA, IL, PCH values, no statistical difference was observed in IW values (**Table 3**).

The evaluation performed calcutating the area below the ROC curve and 95% confidence interval with the aim of determining whether or not clinical measurements such as IPA, IL, IW, PCH and stone size were determiming factors in differentiating the groups in which the procedure was performed successfully and unsuccesfully indicated that IPA was quite a significant determinant, whereas IL, PCH, stone size had lesser degree of significance (**Table 4**).

Multivariate Retrospective Stepwise Elimination Logistic Regression analysis in which all the variables found to be $P < .25$ as a result of the single-variable statistical analyses were included as potential risk factors. Basal model was formed considering the significant variables in single-variable analysis. The variable with the highest $P$ value was not included in the next evaluation. Similarly, the variable with the highest P value was excluded from the evaluation each time. In the end, final model was created. Stone size, IPA and PCH were found as determining factors as a result of the multivariate retrospective stepwise elimination logistic regression analysis (**Table 5**).

**Table 4.** 95 % reliability interval, the area below the ROC curve, the best interception points and the diagnostic performance indicators in relation to IPA, IL, IW, PCH and stone size in differentiating group S from U.

| | IPA | IL | IW | PCH | Size |
|---|---|---|---|---|---|
| ABC | 0.945 | 0.707 | 0,590 | 0.665 | 0.742 |
| %95 RI | 0.905-0.984 | 0.606-0.808 | 0.473-0.707 | 0.553-0.777 | 0.641-0.843 |
| p-value | < 0.001 | < 0.001 | 0.139 | 0.007 | < 0.001 |
| Cut-off value | < 69.4 | > 2.73 | - | > 2.02 | ≥ 17 |
| Number of the cases | 132 | 132 | - | 132 | 132 |
| Sensitivity | 27/29 (93.1%) | 23/29 (79.3%) | - | 22/29 (75.9%) | 17/29 (58.6%) |
| Specificity | 85/103 (82.5%) | 58/103 (56.3%) | - | 61/103 (59.2%) | 82/103 (79.6%) |
| PEV | 27/45 (60.0%) | 23/68 (33.8%) | - | 22/64 (34.4%) | 17/38 (44.7%) |
| NEV | 85/87 (97.7%) | 58/64 (90.6%) | - | 61/68 (89.7%) | 82/94 (87.2%) |

**Abbreviations:** ABC, The Area Below the Curve; RI, Reliability Interval; PEV, Positive Estimated Value; NEV, Negative Estimated Value; IPA, Infundibulopelvic Angle; IL, Infundibular Length; IW, Infundibular Width; PCH, Pelvicaliceal Height.

**Table 5.** Identifying the most important determining factors in differentiating Group S from U according to multivariate retrospective stepwise elimination regression analysis.

| Variables | Odds Rate | %95 Reliability Interval | | Wald | p-value |
|---|---|---|---|---|---|
| | | Upper limit | Lower Limit | | |
| Basal model | | | | | |
| Male factor | 1.675 | 0.315 | 8.916 | 0.366 | 0.545 |
| Multiple stone | 0.729 | 0.074 | 7.172 | 0.074 | 0.786 |
| Stone size ≥ 17 mm. | 8.895 | 0.850 | 93,143 | 3.327 | 0.068 |
| Surgery time | 1. 042 | 0.977 | 1,111 | 1.574 | 0.210 |
| IPA < 69.4 deg. | 50.261 | 8.395 | 300.920 | 18.405 | < 0.001 |
| IL > 2.73 cm. | 2.110 | 0.289 | 15,410 | 0.541 | 0.462 |
| IW | 0.979 | 0.173 | 5.523 | 0.001 | 0.980 |
| PCH > 2.02 cm. | 7.210 | 1.032 | 50.357 | 3.968 | 0.046 |
| SWL | 1.566 | 0.326 | 7.535 | 0.314 | 0.575 |
| Secondary | 5.463 | 0.726 | 41.120 | 2.718 | 0.099 |
| Opaque | 5.156 | 0.605 | 43.910 | 2.252 | 0.133 |
| Model 8 | | | | | |
| Stone size ≥ 17 mm. | 7.647 | 1.790 | 32.672 | 7.539 | 0.006 |
| IPA < 69.4 deg. | 66.569 | 12.128 | 365.408 | 23.352 | < 0.001 |
| PCH > 2.02 cm. | 5.947 | 1.516 | 23.332 | 6.536 | 0.011 |
| Secondary | 3.190 | 0.597 | 17.045 | 1.841 | 0.175 |
| Final model | | | | | |
| Stone size ≥ 17 mm. | 6.476 | 1.659 | 25.285 | 7.225 | 0.007 |
| IPA < 69.4 deg. | 73.197 | 13.588 | 394.296 | 24.968 | < 0.001 |
| PCH > 2.02 cm. | 5.518 | 1.474 | 20.660 | 6.430 | 0.011 |

**Abbreviations:** IPA, Infundibulopelvic Angle; IL, Infundibular Length; IW, Infundibular Width; PCH, Pelvicaliceal Height; SWL, Shock Wave Lithotripsy

## DISCUSSION

The aim of kidney stone management is to remove the stones in the least damaging way possible for the patient. To this end, various methods are used. RIRS is being used more due to absence of incision, shorter hospital stays. A study by Re□orlu et al., compared RIRS and PNL methods in the treatment of kidney stones in children who did not respond to SWL treatment. While no difference was found in terms of the effectiveness of these methods in the stones 2 cm in size or smaller than 2 cm, RIRS was found to be superior to PNL with regard to undesired results such as complications, hospital stay and radiation exposure.[1] In our study one patient had a 54 mm size kidney stone. This patient had a previous stone surgery in the history. The patient had multiple stones in lower calyseal system. And the sum of all stones were measured and defined as the size of the stone.

PNL is recommended in the treatment of larger stones. Although several studies found this method quite successful, some limitations that adversely affect the success of this method are available. The studies carried out on RIRS report lower success rate in lower calyx stones. In this study, we investigated the anatomical factors that affect RIRS success in lower calyx stones. In our study, we showed that gender, age, BMI, ASA scores did not affect RIRS success in lower calyx stones. In consistent with the previous studies, Cannon et al., found similar success rates in prepubertal and postpubertal patients with kidney stone.[3] Dash et al., did not find any significant difference between the success in obese and non-obese patients and the rate of kidney stone absence.[4]

The size and the number of the stones especially multiple stones, previous history of SWL and secondary procedures affect RIRS success in consistent with previous studies in literature. The study by Hyun Lim et al. indicated that stone size, SWL history and secondary procedures affected RIRS success.[2] Stav et al. and Jurg et al. , stated that RIRS was a safe and effective method in SWL resistant kidney stones, however, large stones and lower calyx kidney stones were negative predictor factors that decreased the success of RIRS.[5,6]

The studies related to the impact of pelvicalyceal anatomy in stone treatment are generally carried out on SWL. Sampaio et al. , indicated in their study that IPA< 90 degrees, and IW< 4mm decreased the stone free rate.[7] Elbahnasy indicated that IPA was an important factor in stone removal.[8] Fong et al. indicated that IW was an important determinant in stone removal following SWL.[9] Keeley et al. maintained that IW was not an important factor; however, IPA was an important one.[10]

When we investigated the factors that affect RIRS success, as a result of the multivariate analyses we found that stone size, IPA, PCH factors determine the RIRS success. When the analysis was repeated taking the cut-off value, we found 69.4 degree for IPA, 2.02 cm for PCH and 17 mm for stone size.

A study which investigated the impact of pelvicalyceal anatomy on RIRS success performed on kidney lower calyx stones evaluated the data of 11 out of 67 patients who underwent unsuccessful RIRS and 56 out of 67 patients who underwent successful RIRS IPA and stone size were the factors that affect RIRS success. While difference was observed between the successful and unsuccessful operation groups, this difference was not statistically significant .[11]

Another study about RIRS treatment results and stone free rate examined 66 procedures performed on 63 patients. Stone localization and stone size were found as predictive factors affecting RIRS success. It was found that success rate was lower in lower calyx stones.[2]

Yet another study carried out on the effect of pelvicalyceal anatomy on the success of RIRS examined 47 patients. Patients were divided into 3 groups according to IPA values (< 30 degree, 30-90 degree, > 90 degree). The success of operation was found to be higher in those IPA > 90 degree .The success was above 90 % in this group. IL effect was found statistically significant.[12]

Grasso and Ficazzola evaluated 90 patients who underwent RIRS on lower calyx stone.[13] This study showed that inferior calyx infundibulum larger than 3 cm is itself a determinant factor in RIRS success (Total success was found as 91 %.) Sharp IPA and dilated collecting system were seen as the forcing factors. In 2 patients, infundibular width blocked the entry to calyx.

A study performed with the aim of determining a scoring system for predicting post-RIRS stone free rate examined 207 patients. Patients were divided into groups according to demographic features, stone numbers, stone localizations, pelvicalyceal anatomic factors. The multivariate analysis showed that factors such as stone size, stone content, number of stones, IPA, renal malformation affected RIRS success. 88 out of 207 patients had lower calyx stones and operations in 19 of these patients were unsuccessful.[14]

In our study, since the operation success in lower calyx stones was lower than the stones in the other calyx, we examined patients with isolated lower calyx stones. Since the patients with renal malfunction and multiple calyxes were excluded from the study, those factors could not be assessed.

In parallel with the studies in the literature, we concluded that IPA and stone size were factors that affected RIRS success in lower calyx stones. Different from the studies in literature, we indicated that PCH was a factor that affected RIRS success. In a study performed with SWL, stone free rate was 92 % in patients with PCH<15 and 52 % in patients with PCH≥15mm in a study carried out on SWL.[15]

No complication arose in either group in our study. When we look at the limitations of our study, the disadvantages include that it was performed retrospectively; unfortunately we did not have any information about the technical difficulties. Patients were evaluated with IVU and the number of the patients. In a study carried out on SWL, patients were evaluated using IVU and Helical CT (HCT). In lower calyceal anatomy evaluation, it was seen that 3D-HCT was not superior to IVU. We chose IVU over 3D-HCT because of lower costs of IVU compared to 3D-HCT and the high radiation dose in 3D-HCT.[16] In our study we intended to determine the anatomical factors affecting RIRS success. Therefore, we did not evaluate the hounsfield units.

There is no study in literature performed with the same patient number like our study which investigated the anatomical factors that affected RIRS success.

European Association of Urology 2014 stone treatment guideline recommends RIRS or PNL in case that SWL is not suitable in lower calyx stones larger than 1.5 cm .[17] PNL is an effective method with high success rates. However, serious complications might be seen during and post PNL procedure. This makes the doctors prefer RIRS method, which is a rapidly evolving method. RIRS is used more and more due to its increasing success rates, short hospital stay and being less invasive. However, RIRS is not a successful method in all patients. Patient selection is important for RIRS success. Otherwise, kidney stones can be treated after multiple sessions.

## CONCLUSIONS

IPA is an important factor in predicting the success of lower kidney calyx stones. It affects the success of RIRS to a great extent. Additionally, stone size and PCH, although not as important as IPA, are important in predicting the success of RIRS. RIRS should not be preferred for kidney stone management in patients with low IPA, high PCH and stone size.

The patients whose IPA, PCH and stone size vales are unsuitable may need multiple RIRS or additional treatment modalities.

## CONFLICT OF INTEREST

There is no conflict of interest among the authors.

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