Review

*Arch. Esp. Urol.* 2023; 76(2): 107–113
https://doi.org/10.56434/j.arch.esp.urol.20237602.11

# Does Time and Size Matter in Retrograde Intrarenal Surgery? Results Analysis Using a Low-Pressure Technique

Paula Gayarre Abril[1,*], Benjamín Blasco Beltrán[1], Daniel Hijazo Gascón[1], Jorge Subirá Ríos[1], Victoria Capapé Póves[1], Carlos Blanco Chamorro[1], Maria Rut Sieso Gracia[1], Francisco Xavier Elizalde Benito[1], Gonzalo Abril Baquero[1], Patricia Carrera Lasfuentes[1], Jorge Rioja Zuazu[1,2]

[1]Urology Service, University Clinic Hospital "Lozano Blesa", 50009 Zaragoza, Spain
[2]Department of Surgery, University of Zaragoza, 50009 Zaragoza, Spain
*Correspondence: paula17893@hotmail.com (Paula Gayarre Abril)
Published: 28 March 2023

**Purpose: Kidney stone disease affects 5% of the population and is associated with non-negligible morbidity. Retrograde intrarenal surgery and percutaneous nephrolithotomy are the treatments of choice. We analyzed the results from our patients who underwent retrograde intrarenal surgery at controlled pressure.**

**Materials and Methods: We conducted an observational, descriptive, retrospective study of 403 patients who underwent retrograde intrarenal surgery at the Hospital Clínico Universitario Lozano Blesa (Zaragoza, Spain) between January 2013 and December 2019.**

**Results: The mean surgical time was 111.1 minutes, with a mean stone volume of 3.5 $cm^3$ (maximum volume, 38.3 $cm^3$). A total of 70 patients (17.3%) developed postoperative Clavien-Dindo complications—64 minor (91.4%) and 6 major (8.6%). In addition, 28 patients (6.9%) presented with an early complication (<3 months), with urinary tract infection and pyelonephritis being the most common. The stone-free rate was 69.0%, with a retreatment rate of 4.7%.**

**Conclusions: Sex was statistically significantly related to the onset of minor Clavien postoperative complications ($p$ = 0.001). Similarly, corticosteroid use was associated with the onset of major Clavien complications ($p$ = 0.030). Neither surgical time nor stone volume was found to be statistically significantly related to the onset of Clavien postoperative complications or early complications.**

**Keywords:** retrograde intrarenal surgery; low pressure; complications; surgical time

## Introduction

Kidney stone disease is characterized by the formation of calculi in the urinary tract. Its incidence in resource-rich countries is high, affecting up to 5% of the population [1,2], with relapse rates in the range of 24% to 50% depending on the series and peak incidence between the third and fourth decades of life [3,4].

The European Association of Urology (EAU) guidelines [5] consider percutaneous nephrolithotomy (PCNL) the treatment of choice for kidney stones greater than 2 cm in size, though PCNL is not devoid of complications and requirement for skills. Retrograde Intrarenal Surgery (RIRS) [6,7] affords a comparable success rate, causes fewer complications than percutaneous nephrolithotomy (PNL), and seems to be a promising alternative to PNL when larger stones are to be treated.

### *Intrarenal Pressure during Endourologic Surgery*

Retrograde intrarenal surgery and PCNL are the 2 most widely used endourologic techniques for treating kidney stones, although both require increasing irrigation flow and pressure to distend cavities and allow optimal visibility during surgery, which results in an increased intrarenal pressure (IRP) that may cause postoperative complications. Increasing intravesical pressures result in an increase in IRP; Therefore, draining the bladder is recommended in any endourologic procedure [7–9].

#### Retrograde Flow

Hinman and Redewill [9] demonstrated the existence of retrograde flow at pressures of 40.8 to 47.6 mm Hg in a canine model. Subsequent studies showed that this phenomenon can occur at pressures of up to 13.6 mm Hg [10,11]. In a porcine model, a clear retrograde flow appeared at an IRP of 272 mm Hg, which led to rupture of

the fornix. Several factors, including ischemic disease, low urinary flow, or vesicoureteral reflux, favor high pressures and therefore may produce retrograde flow [12,13].

Role of IRP in Kidney Damage and Systemic Complications

High IRP has been associated with denudation of the calyceal urothelium; Rupture of the fornix and parenchyma, which favors the onset of subcapsular hematomas or leaks and is a risk factor for postoperative fever and sepsis [14, 15]. Finally, high IRP can result in decreased flow in the renal vein and compression of the renal microvasculature, which in turn may lead to ischemic kidney damage [16–19].

In light of all these points, we aimed to analyze the results obtained in our series of patients who underwent RIRS at controlled pressure; Study the factors that may affect the onset of immediate postoperative complication, identify the correlation, if any, between infectious complications and urinary cultures before surgery; And evaluate the stone-free rate (SFR) as a function of stone volume.

## Materials and Methods

### *Study Design*

We conducted an observational, descriptive, retrospective study made up of 403 patients who underwent RIRS at the Hospital Clínico Universitario (HCU) Lozano Blesa (Zaragoza, Spain) between January 2013 and December 2019.

### *Study Population*

Patient candidates for RIRS treatment were selected according to the criteria the Urology Department at HCU Lozano Blesa had established based on EAU guideline recommendations [5]. The Lithotripsy Unit at the HCU Lozano Blesa is the reference center for treatment of kidney stone disease for the autonomous community of Aragon.

Inclusion criteria were as follows: Candidacy for RIRS irrespective of stone size. The exclusion criteria were (1) RIRS with diagnostic rather than therapeutic intent, (2) therapeutic RIRS for urothelial tumors (either biopsy or photovaporization), (3) RIRS in which the target stone has been expelled, and (4) RIRS in which access to the renal cavities in a first attempt through a stenotic or diseased ureter is not possible.

### *Study Variables*

Our study considered the following primary variables:

- Total stone volume ($mm^3$) for all stones determined using the following formula:

$$Stone\ volume = number\ \pi/6 \times Height \times Width \times Length$$

- Surgical time (minutes)

- Clavien-Dindo complications (0 = no complications; 1 = minor complications; 2 = major complications)

- Early complications (0 = no; 1 = yes) (Early complications were defined as those appearing in the first 3 months after surgery.)

- SFR (Y = yes; N = no) (Patients with stone fragments $<2$ mm were considered stone free.)

In addition, we studied variables related to the patient, the surgical procedure, and other variables (haematuria postoperatively, pain after surgery, postoperative tachycardia, systolic and diastolic blood pressure for 24 h postoperatively, and hospital stay).

### *Surgical Technique*

Retrograde intrarenal surgery consists of endourological treatment for kidney stones by a retrograde transureteral approach. The irrigation pump is first purged at 100 mm Hg for 1 minute, then programmed at 25 mm Hg with 0.9% saline solution. The pump (Arthrex Continuous Wave III Arthroscopy Pump, model AR-6475; Erwin-Hielscher-Strasse 981249, München, Germany) is an open-system, continuous-flow irrigation pump with no pressure pulses that stops irrigation when the irrigation pressure reaches the same value as the region irrigated.

Preoperative antibiotic prophylaxis is based on a urine culture performed 7 to 10 days before surgery. Subsequently, with the patient in the lithotomy position and under general anesthesia, a semirigid ureteroscopy is performed using a hydrophilic guide wire (Sensor, Boston Scientific, Marlborough, MA, USA) previously introduced into the renal cavities under fluoroscopy. In the event of concomitant ureteral stones or kidney stones that can be treated with a semirigid ureteroscope (Olympus ureteroscope, Hamburgo, Germany; Wolf ureteroscope, Knittlingen, Germany; or Storz ureteroscope, Madrid, Spain), this scope is inserted in parallel to a safety guide wire, and stone vaporization is performed using a holmium laser 400 $\mu$m (Dornier MedTech, Barcelona, Spain) until fragments smaller than 2 mm are obtained.

In the case of stones that cannot be treated using a semirigid ureteroscope, a ureteral sheath (12–14 Fr (ReTrace, Coloplast)) is advanced over a guide wire to the proximal ureter under fluoroscopy. Then, a flexible ureteroscope is introduced (flexible digital URF-V Olympus 8.5/9.9-Fr ureteroscope, with tip flexion of 180° upwards and 260° downwards, rotation of up to 90° in the insertion tube, a 3.5-Fr working channel and irrigation channel, and a working length of 670 mm) through the ureteral sheath. The irrigation pump is at 40 mm Hg. The renal cavities are explored until all treatable kidney stones have been identified and vaporized using the 200-$\mu$m holmium laser fiber. The laser settings for each treatment were the same. Finally, a double-J ureteral catheter is placed on the guide wire under fluoroscopy.

*Postoperative Monitoring*

For postoperative evaluation of surgical outcome, a plain radiograph was taken 4 to 6 weeks after surgery, with concomitant evaluation of postoperative complications from the date of surgery. In addition, in our project other early complications, like pyelonephritis, urinary infection, or renal colic, were evaluated during the 3 months after.

In the event of an absence of fragments in the imaging test or if the fragments were expellable, the SFR was recorded and the double-J ureteral catheter was removed by cystoscopy. Surgical success, or SFR, was considered the absence of residual stones or the presence of fragments smaller than 2 mm in diameter in the control examination. Finally, therapeutic recommendations for the prophylaxis of stone relapse were provided.

## Results

Of the 403 patients included in our study, 202 were female and 201 were male, with a mean age of 56.9 ± 16.3 years. An analysis of the medical history of the series revealed that 35.2% of patients presented with at least 1 condition, with type 2 diabetes and active smoking being the most prevalent (Table 1).

**Table 1. Demographic and clinical variables of study patients.**

| Variable | No. (%) |
|---|---|
| Sex (male) | 201 (49.9) |
| Type 2 diabetes | 79 (19.6) |
| Active smoker | 70 (17.4) |
| IBD | 2 (0.5) |
| Corticosteroids | 2 (0.5) |
| Bariatric surgery | 3 (0.7) |
| Bilateral stones | 5 (1.2) |
| Staghorn stones | 31 (7.7) |
| Prior double-J catheter | 163 (40.4) |
| Presurgical UC Yes | 264 (65.5) |
| Positive | 81 (30.6) |
| Negative | 183 (69.3) |
| Age, mean ± SD, y | 56.9 ± 16.3 |
| Stone volume, mean ± SD, $cm^3$ | 3.5 ± 5.4 |
| Maximum diameter, mean ± SD, cm | 1.8 ± 1.1 |

Abbreviations: IBD, inflammatory bowel disease; UC, urine culture; SD, standard deviation.

The mean stone volume was 3.5 ± 5.4 $cm^3$, with a maximum of 38.3 $cm^3$. Only 65.5% of presurgical urine cultures were recorded, with 30.7% of these cultures positive for at least 1 microorganism. The clinical variables are presented in Table 1.

The mean surgical time was 111.1 minutes, with a maximum of 330 minutes. Both ureteroscopes were used in 75.2% of cases. As regards intraoperative complications, 2 patients experienced a leak of contrast agent, and 1 had frank hematuria.

**Table 2. Clavien-Dindo postoperative complications and early complications.**

| | Frequency | % |
|---|---|---|
| No complications | 333 | 82.6 |
| Minor complications | 64 | 15.8 |
| Clavien 1 | 40 | 9.9 |
| Clavien 2 | 24 | 6.0 |
| Major complications | 6 | 1.5 |
| Clavien 3 | 0 | 0 |
| Clavien 4 | 5 | 1.2 |
| Clavien 5 | 1 | 0.2 |
| Early complications (<3 mo) | 28 | 6.94 |
| Urinary symptoms | 2 | 0.49 |
| Renal colic | 5 | 1.24 |
| Pyelonephritis | 7 | 1.73 |
| UTI | 11 | 2.72 |
| Hematuria | 1 | 0.2 |
| AUR | 1 | 0.2 |
| Death (edema of the glottis) | 1 | 0.2 |

Abbreviations: AUR, acute urinary retention; UTI, urinary tract infection.

Regarding the onset of Clavien-Dindo postoperative complications, 70 patients developed some type of complication, mostly minor (91.4%); Only 6 patients presented with a major complication. Patient distribution by complication is shown in Table 2.

The mean hospital stay was 2 ± 3.4 days, with a maximum stay of 60 days in the case of a patient who had to be admitted to the intensive care unit (ICU) and intubated. The patient required a subsequent tracheostomy because of poor evolution.

A total of 28 patients presented with some type of early complication (<3 months), with urinary tract infection (UTI) and pyelonephritis being the most common (Table 2). An SFR was achieved in 69% of the series, with a retreatment rate of 4.7%.

Age was not found to be statistically significantly associated with the onset of Clavien-Dindo complications, whereas sex was associated with a higher risk of developing minor Clavien-Dindo complications ($p = 0.001$). Only corticosteroid use was associated with a higher risk of developing major Clavien-Dindo complications ($p = 0.030$). Neither surgical time was no stone volume statistically significantly associated with the onset of Clavien-Dindo complications (Table 3).

Age, sex, and medical history were not statistically significantly associated with onset of early complications. Similarly, neither surgical time nor stone volume were statistically significantly associated with the onset of early complications (Table 4).

**Table 3. Influence of factors associated with Clavien-Dindo postoperative complications.**

| Variable | No complications (n = 333) | Complications (n = 70) | *p* value |
|---|---|---|---|
| Male sex, No. (%) | 180 (54.1) | 21 (30.0) | <0.001 |
| Type 2 diabetes, No. (%) | 69 (20.7) | 10 (14.3) | 0.249 |
| Active smoker, No. (%) | 59 (17.7) | 11 (15.7) | 0.862 |
| IBD, No. (%) | 2 (0.6) | 0 (0.0) | 1.000 |
| Corticosteroids, No. (%) | 1 (0.3) | 1 (16.7) | 0.318 |
| Bariatric surgery, No. (%) | 2 (0.6) | 1 (1.4) | 0.437 |
| Age, mean ± SD, y | 57.3 ± 16.1 | 55.1 ± 17.3 | 0.304 |
| Surgical time, mean ± SD, min | 109.4 ± 47.3 | 118.9 ± 50.2 | 0.174 |
| Stone volume, mean ± SD, $cm^3$ | 3.4 ± 5.4 | 4.3 ± 5.6 | 0.105 |

Abbreviation: IBD, inflammatory bowel disease.

**Table 4. Influence of factors associated with early complications (<3 months).**

| Variable | No complications (n = 333) | Complications (n = 70) | *p* value |
|---|---|---|---|
| Male sex, No. (%) | 189 (50.4) | 12 (42.9) | 0.557 |
| Type 2 diabetes, No. (%) | 76 (20.3) | 3 (10.7) | 0.323 |
| Active smoker, No. (%) | 63 (16.8) | 7 (25.0) | 0.299 |
| IBD, No. (%) | 2 (0.5) | 0 (0.0) | 1.000 |
| Corticosteroids, No. (%) | 2 (0.5) | 0 (0.0) | 1.000 |
| Bariatric surgery, No. (%) | 3 (0.8) | 0 (0.0) | 1.000 |
| Age, mean ± SD, y | 57.2 ± 16.2 | 53.5 ± 18.2 | 0.298 |
| Surgical time, mean ± SD, min | 110.8 ± 47.6 | 113.0 ± 52.8 | 0.892 |
| Stone volume, mean ± SD, $cm^3$ | 3.5 ± 5.3 | 4.7 ± 6.6 | 0.780 |

Abbreviation: IBD, inflammatory bowel disease.

## Discussion

Recent progress in the design of ureteroscopes, increased use of holmium lasers, and improvements in surgical skill have allowed us to expand the indications for RIRS, initially limited to diagnosis, to include the treatment of ureteral and intrarenal stones, thus providing a good alternative to PCNL. A complication rate of 10%, with the majority of these complications being minor on the Clavien scale, compared with 20.5% for PCNL means that more physicians have begun to treat stones measuring more than 2 cm by RIRS, often obtaining stone removal rates exceeding 90%, thus making this technique an excellent alternative [20].

Compared with the literature reviewed, the importance of this study lies in the number of cases included, the success rate obtained, and the limited number of complications.

Furthermore, our series consisted of 403 patients, all of whom underwent RIRS as treatment for kidney stones. The mean stone volume in our series was 3.5 $cm^3$, with a maximum volume of 38.3 $cm^3$ and a mean stone diameter of 1.8 cm. Approximately 7.7% of patients presented with staghorn stones. Among the numerous publications in this area, the most relevant are the series reported by Palmero *et al.* [20], which included 106 patients and found a mean stone diameter of 2.46 cm; Hyams *et al.* [21], with 120 cases and a mean diameter of 2.4 cm; Al-Qahtani *et al.* [22], with 104 cases and a mean stone diameter of 2.6 cm, and Traxer *et al.* [23] with 359 patients.

A total of 164 patients had required emergency urinary diversion because of a complicated renal colic. All these cases involved insertion of a double-J catheter except 1, which required an emergency nephrostomy. Some authors in the literature recommend insertion of a double-J catheter before surgery to ensure passage of the ureteral sheath [20]. Traxer *et al.* [23] ensured pre-stenting vs. no pre-stenting decreased the risk of severe injury by sevenfold. In our experience, and given our surgical technique, we do not consider this step necessary, and we do not know whether the prior emergency catheterization had any effect on the subsequent surgery.

In our series, surgical time (mean, 111.1 minutes) was slightly shorter than the 112 minutes reported by Palmero *et al.* [20]; And higher than the 82 minutes reported by Aboumarzouk *et al.* [24]. All surgeries were performed with the same surgical technique, which is commonly used in our department and described in detail in the "Materials and Methods" section. All procedures started with the systematic use of a semirigid ureteroscope; A ureteral sheath was inserted only in the case of inaccessible stones or poor visibility to continue using a flexible ureteroscope. A continuous-flow irrigation pump with no pressure pulses was used at all times; 75.2% of interventions required the use of both ureteroscopes. We are convinced that the complication rate decreases markedly when a continuous-flow

irrigation pump is used to help maintain good visibility and facilitate working at low pressure.

Regarding Clavien-Dindo postoperative complications, the overall rate was low (17.3%). A total of 70 patients developed some type of complication, which in most cases was minor (91.4%), and only 6 patients (1.5%) developed a major complication, with 5 of these patients being admitted to the ICU for close monitoring and 1 dying from a cause unrelated to the surgery. The series by Palmero *et al*. [20] and Cepeda *et al*. [1] reported complication rates of 6.7% and 14.6%, respectively, most of which were grade 1 or 2 in the Clavien classification. Overall complication rate of Aboumarzouk *et al*. [24] was 10.1%, with major complications developed in 21 (5.3%) patients and minor complications developed in 19 (4.8%). As such, our findings closely resemble those reported for other large series, which found complication rates of approximately 10%.

In our study, we defined success, or SFR, as the absence of stones or residual stones measuring less than 2 mm in postsurgical radiologic controls, a rate we achieved in 69% of patients. Similarly, Palmero *et al*. [20] and Hyams *et al*. [21] reported success rates of 73.6%, although the cutoffs for residual stones were 5 mm or 4 mm, respectively. There is still no consensus because there are authors who consider success to be sizes below 2 mm [22,25,26]; However, other authors, such as Hyams *et al*. [21], place success at 4 mm.

Our retreatment rate of 4.71% was higher than the value (1.7%) that Palmero *et al*. [20] reported and the values seen in other studies in the literature.

### *Influence of Perioperative Factors on the Onset of Clavien-Dindo Postoperative Complications and Early Complications*

Our analysis of the effect of postoperative factors on the onset of Clavien-Dindo postoperative complications showed that age exhibited no statistically significant relationship, whereas sex was associated with a higher risk of developing minor Clavien-Dindo postoperative complications (grades 1 and 2), mainly nausea, vomiting, pain, or UTI. In the case of women, this finding can be explained by the known higher incidence of UTIs in this group. Traxer *et al*. [23], reported Body mass index, a history of diabetes mellitus, vascular disease or abdominopelvic radiation therapy and operative time were not associated with postoperative complications.

Our findings showed a statistically significant association between corticosteroid use and the development of major Clavien complications, with 1 patient on corticosteroids developing a major complication. This patient was presumably a complex pluripathologic patient, however, which could be considered an independent risk factor for the development of such complications. Moreover, as this sample comprised just 1 patient, the probability is high that it is insufficient to unequivocally determine a link between corticosteroid use and the development of major Clavien complications representative of the wider population.

Neither surgical time nor stone volume were statistically significantly related to the development of Clavien-Dindo complications ($p = 0.174$, $p = 0.105$ respectively), which supports our proposal that the rate of complications decreases markedly when using a continuous-flow irrigation pump to maintain good visibility, with surgical time and stone volume being independent of the onset of such complications.

Maybe the result was not statistically significantly associated because the rate of patients who developed some type of Clavien-Dindo major complications was low, only six patients (1.5%).

Surgical time and stone volume were not statistically significantly associated with onset of early complications ($p = 0.892$, $p = 0.780$ respectively).

Finally, the rest of our analysis of the effect of perioperative factors on the onset of early complications (<3 months) showed that none of the factors we analyzed exhibited any statistically significant relationship.

### *Limitations*

The main limitation of our study was the access to data and diagnostic test. This review was a retrospective study, so we could not have access to some test like presurgical urine cultures. 65.5% of presurgical urine cultures were recorded, with 30.7% of these cultures were positive. So that was a limitation to made heavy conclusions.

At last, our study was not have a control group, so this condition prevent us to state some heavy conclusions.

## Conclusions

In this descriptive study, we analyzed the results obtained in our series of patients who underwent RIRS at controlled pressure and the development of complications.

Sex is associated with a higher risk of developing minor (grades 1 and 2) Clavien-Dindo postoperative complications. Surgical time and stone volume were not statistically significantly related to the onset of either postoperative Clavien-Dindo or early complications.

The stone free rate (SFR) was achieved in 69% of patients. The repetition of intraoperative antibiotic prophylaxis 2 h after the start of surgery may be an interesting factor to consider for future protocols.

## Abbreviations

EAU, European Association of Urology; RIRS, retrograde intrarenal surgery; PCNL, percutaneous nephrolithotomy; IRP, intrarenal pressure; SFR, stone-free rate; UTI, urinary tract infection; UC, urine culture; ICU, intensive care unit; IBD, inflammatory bowel disease.

## Author Contributions

PGA—Protocol/project development, data collection or management, data analysis, manuscript writing/editing, major contribution for submitting this paper; BBB and DHG—Protocol/project development, data collection or management; JSR, VCP, CBC, MRSG, FXEB and GAB—Protocol/project development; PCL—Protocol/project development, data analysis, manuscript writing/editing; JRZ—Protocol/project development, manuscript writing/editing. All authors read and approved the manuscript.

## Ethics Approval and Consent to Participate

This project is not a clinical trial, it is an observational, descriptive, and retrospective study made up of 403 patients who underwent RIRS at the Hospital Clínico Universitario. We aimed to analyze the results obtained in our series of patients who underwent RIRS at controlled pressure. The publication of this study was approved by the Ethics Committee of Aragon (CEICA). All patients had signed the informed consent for surgery.

## Acknowledgment

Not applicable.

## Funding

This research received no external funding.

## Conflict of Interest

The authors declare no conflict of interest.

## References

[1] Cepeda M, Amón JH, Mainez JA, Rodríguez V, Alonso D, Martínez-Sagarra JM. Flexible ureteroscopy for renal stones. Actas Urologicas Españolas. 2014; 38: 571–575.

[2] Huang J, Xie J, Huang X, Yuan Q, Jiang H, Xiao K. Flexible ureteroscopy and laser lithotripsy for renal stones 2 cm or greater: A single institutional experience. Medicine. 2020; 99: e22704.

[3] Lai D, Chen M, He Y, Li X, Wan S. Safety and efficacy of retrograde intrarenal surgery for the treatment of renal stone in solitary kidney patients. Renal Failure. 2018; 40: 390–394.

[4] Amón JH, Cepeda M, Conde C, Alonso D, González V, Martínez-Sagarra JM. Retrograde intrarenal surgery (RIRS). Technical complement for cases of acute lithiasis. Actas Urológicas Españolas. 2011; 35: 108–114.

[5] Türk C, Petřík A, Sarica K, Seitz C, Skolarikos A, Straub M, *et al*. EAU guidelines on interventional treatment for urolithiasis. European Urology. 2016; 69: 475–482.

[6] Zengin K, Tanik S, Karakoyunlu N, Sener NC, Albayrak S, Tuygun C, *et al*. Retrograde Intrarenal Surgery versus Percutaneous Lithotripsy to Treat Renal Stones 2–3 cm in Diameter. BioMed Research International. 2015; 2015: 914231.

[7] Whitaker RH. Methods of assessing obstruction in dilated ureters. British Journal of Urology. 1973; 45: 15–22.

[8] Kiil F. Pressure Recordings in the Upper Urinary Tract. Scandinavian Journal of Clinical and Laboratory Investigation. 1953; 5: 383–384.

[9] Hinman F, Redewill FH. Pyelovenous back flow. Journal of the American Medical Association. 1926; 87: 1287–1293.

[10] Kukreja RA, Desai MR, Sabnis RB, Patel SH. Fluid absorption during percutaneous nephrolithotomy: does it matter? Journal of Endourology. 2002; 16: 221–224.

[11] Stenberg A, Bohman SO, Morsing P, Müller-Suur C, Olsen L, Persson AE. Back-leak of pelvic urine to the bloodstream. Acta Physiologica Scandinavica. 1988; 134: 223–234.

[12] Thomsen HS, Dorph S, Olsen S. Pyelorenal Backflow in Normal and Ischemic Rabbit Kidneys. Investigative Radiology. 1981; 16: 206–214.

[13] Hodson CJ. The Effects of Disturbance of Flow on the Kidney. Journal of Infectious Diseases. 1969; 120: 54–60.

[14] Jung HU, Frimodt-Møller PC, Osther PJ, Mortensen J. Pharmacological effect on pyeloureteric dynamics with a clinical perspective: a review of the literature. Urological Research. 2006; 34: 341–350.

[15] Schwalb DM, Eshghi M, Davidian M, Franco I. Morphological and Physiological Changes in the Urinary Tract Associated with Ureteral Dilation and Ureteropyeloscopy: an Experimental Study. Journal of Urology. 1993; 149: 1576–1585.

[16] Li X, Liu M, Bedja D, Thoburn C, Gabrielson K, Racusen L, *et al*. Acute renal venous obstruction is more detrimental to the kidney than arterial occlusion: implication for murine models of acute kidney injury. American Journal of Physiology. Renal Physiology. 2012; 302: F519–F525.

[17] Park Y, Hirose R, Dang K, Xu F, Behrends M, Tan V, *et al*. Increased severity of renal ischemia-reperfusion injury with venous clamping compared to arterial clamping in a rat model. Surgery. 2008; 143: 243–251.

[18] Tokas T, Herrmann TRW, Skolarikos A, Nagele U, Training and Research in Urological Surgery and Technology (T.R.U.S.T.)-Group. Pressure matters: intrarenal pressures during normal and pathological conditions, and impact of increased values to renal physiology. World Journal of Urology. 2019; 37: 125–131.

[19] Tokas T, Skolarikos A, Herrmann TRW, Nagele U, Training and Research in Urological Surgery and Technology (T.R.U.S.T.)-Group. Pressure matters 2: intrarenal pressure ranges during upper-tract endourological procedures. World Journal of Urology. 2019; 37: 133–142.

[20] Palmero JL, Castelló A, Miralles J, Nuño de La Rosa I, Garau C, Pastor JC. Resultados de la cirugía retrógrada intrarrenal en el tratamiento de litiasis renales mayores de 2 cm. Actas Urológicas Españolas. 2014; 38: 257–262.

[21] Hyams ES, Munver R, Bird VG, Uberoi J, Shah O. Flexible ureterorenoscopy and holmium lithotripsy for the management of renal stone burdens that measure 2 to 3 cm: a multi-institutional experience. Journal of Endourology. 2010; 24: 1583–1588.

[22] Al-Qahtani SM, Gil-deiz-de-Medina S, Traxer O. Predictors of Clinical Outcomes of Flexible Ureterorenoscopy with Holmium Laser for Renal Stone Greater than 2 cm. Advances in Urology. 2012; 2012: 543537.

[23] Traxer O, Thomas A. Prospective Evaluation and Classification of Ureteral Wall Injuries Resulting from Insertion of a Ureteral Access Sheath during Retrograde Intrarenal Surgery. Journal of Urology. 2013; 189: 580–584.

[24] Aboumarzouk OM, Monga M, Kata SG, Traxer O, Somani BK. Flexible ureteroscopy and laser lithotripsy for stones >2 cm: a systematic review and meta-analysis. Journal of Endourology. 2012; 26: 1257–1263.

[25] Riley JM, Stearman L, Troxel S. Retrograde ureteroscopy for renal stones larger than 2.5 cm. Journal of Endourology. 2009; 23: 1395–1398.

[26] Hussain M, Acher P, Penev B, Cynk M. Redefining the limits of flexible ureterorenoscopy. Journal of Endourology. 2011; 25: 45–49.