

Comparison of the Effects of Multiple Retrograde Intrarenal Surgery and Single Access Conventional Percutaneous Nephrolithotomy Operation on Early Acute Kidney Injury

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What's known on the subject? and What does the study add?

Conventional percutaneous nephrolithotomy (PCNL) may be risky in causing acute kidney injury (AKI), which is correlated with the number of accesses required. This study emphasized that similar to single-access PCNL, multiple sessions of retrograde intrarenal surgery (RIRS) can be recommended as an alternative method for AKI for kidney stones of similar size.

Abstract

Objective: This study compares the impact of multiple sessions of retrograde intrarenal surgery (RIRS) and a single access conventional percutaneous nephrolithotomy (PCNL) on acute kidney injury (AKI) in patients with nephrolithiasis.

Materials and Methods: Patients who underwent multiple RIRS within 3 months, in the same renal unit and single access PCNL operations between January 2018 and December 2023, were retrospectively included in the study. Patients were compared in terms of demographic (age, gender, body mass index, comorbidities) and clinical (stone volume, stone size, stone density, stone location, and operation time) characteristics. Serum creatinine levels were measured in the preoperative period and on the first postoperative day in all patients, and estimated glomerular filtration rates (eGFR) was calculated. The mean creatinine values were calculated and evaluated in patients who underwent multiple RIRS. The data were analyzed comparatively.

Results: Two hundred one patients underwent PCNL, and 163 patients underwent multiple RIRS. Of the patients who underwent RIRS, 148 underwent two surgeries, ten underwent three surgeries, four underwent four surgeries, and one underwent five surgeries. AKI developed in 6 (3.0%) PCNL patients and 3 (5.2%) RIRS patients within 48 hours of surgery. The demographic and operational results of the patients were statistically comparable ($p>0.05$). In PCNL cases, the rise in creatinine and the decrease in eGFR were greater than in RIRS cases; however, no statistically significant difference was seen ($p=0.054$ and $p=0.057$, respectively).

Conclusion: Multiple RIRS and single-access PCNL are comparable regarding AKI. Repeated RIRS is a feasible method for large kidney stones, that can be used safely, like PCNL, in suitable patients.

Keywords: Basic science, endourology, general urology, retrograde intrarenal surgery, percutaneous nephrolithotomy, acute kidney injury, kidney stone

Introduction

Nephrolithiasis is an integral aspect of everyday urologic practice, with a prevalence estimated between 1% and 13% in various global locations and 11.1% in Türkiye (1). Significant

advancements have occurred in the treatment options for nephrolithiasis in recent years. Percutaneous nephrolithotomy (PCNL) is regarded as the gold standard therapy for upper urinary tract calculi over 2 cm (2). Although retrograde intrarenal surgery (RIRS) is routinely recommended for kidney stones smaller than

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2 cm, it has begun to be used with increasing frequency for larger stones with developing laser technology, and increased scope sophistication.

The minimally invasive characteristics of the PCNL treatment are coupled with greater effectiveness and a reduced complication rate. The influence of PCNL on renal function has been contentious. While stone removal often improves baseline renal function by alleviating blockage and addressing underlying infection (3), acute kidney injury (AKI) has been documented as a significant consequence of the PCNL operation. If this surgery is performed with multiple access points to the kidney, theoretically, AKI may deepen due to the parenchymal defect. However, there is a lack of literature regarding the effect of RIRS on kidney damage (4). RIRS-related complications vary from 9% to 25%, most of which are minor issues that do not need intervention, including fever, infection, hematuria, and postoperative pain (5). The rate of complications associated with PCNL, a more invasive technique, ranges from 3% to 34%. The incidence of RIRS-related problems may be linked to the progressive rise in its use (6).

The 2012 Kidney Disease: Improving Global Outcomes (KDIGO) clinical practice guideline categorizes AKI into three phases based on serum creatinine increase or reduction in urine output. AKI was defined as an increase in serum creatinine level of ≥ 0.3 mg/dL within 48 hours (7). This categorization approach has recently been evaluated in many published papers. This study aimed to compare the effects of repeated RIRS and single-access PCNL operations on early AKI.

Materials and Methods

With the approval of the Tekirdağ Namık Kemal University Non-Interventional Clinical Research Ethics Committee (number: 2024.265.09.15, date: 09.24.2024), patients who underwent multiple RIRS within the same renal unit within 3 months and single-access PNL operations, due to kidney stones in a single center between January 2018 and December 2023, were retrospectively included in the study. The only inclusion condition was RIRS for nephrolithiasis, while the exclusion criteria included individuals under 18 years of age, end-stage renal illness, solitary kidneys, and a single intervention. Similar exclusion criteria were applied for PCNL, but in addition, patients with multiple accesses to the same kidney were excluded.

All patients had a preoperative assessment following a standardized procedure, which included informed written consent, a full medical history, a physical examination, serum creatinine test, urinalysis, urine culture, and non-contrast computed tomography (NCCT). The volume and density of stones were assessed using NCCT images (8). All surgical interventions were performed under general anesthesia. Prophylactic

injection of 2 grams intravenous third-generation cephalosporin (Ceftriaxone) antibiotics was usually administered around one hour prior to the surgical procedure.

Patient demographic and clinical data, including age, existence of concomitant systemic disorders, body mass index, stone location, stone size, Hounsfield units, preoperative and postoperative serum creatinine levels, and estimated glomerular filtration rates (eGFR) were compared. Serum creatinine levels were measured in all patients during the preoperative period and on the first postoperative day, followed by the calculation of eGFR. In patients who underwent multiple RIRS, mean creatinine values were evaluated. Data were analyzed comparatively.

Surgical Technique of Retrograde Intrarenal Surgery

All RIRS operations were conducted by an experienced surgeon (CMY). Patients were positioned in the lithotomy position and underwent active dilation via an 8-French semi-rigid ureteroscope (Karl Storz, Tuttlingen, Germany). Following the placement of the safety guidewire (0.035 inches), a standard 11-13 Fr Navigator HD (Boston Scientific, Marlborough, MA) ureteral access sheath (UAS) of either 36 or 46 cm was inserted over the guidewire, just below the ureteropelvic junction under fluoroscopy. In instances with ureteral diseases obstructing preventing the passage of a UAS, a JJ stent was inserted, and the procedure was delayed for two weeks. An 8.5 Fr reusable digital flexible ureteroscope (Flex-XC, Karl Storz, Tuttlingen, Germany) was placed into the UAS. The stones were fragmented using a 272 μ m Holmium: YAG laser (Quanta System, Litho, Milan, Italy) until the pieces were small enough to pass out spontaneously. At the end of the procedure, a JJ stent was inserted, and it was removed postoperatively in the third week in the office.

Surgical Technique of Percutaneous Nephrolithotomy

PCNL operations were also performed by the same surgeon (CMY). Using cystourethroscopy performed in the lithotomy position, a standard 5 Fr ureteral catheter was placed into the ureter with a guidewire under fluoroscopy. Then, the patient was placed in the prone position. A retrograde contrast agent was introduced to the kidney with 18-gauge Chiba needles for access. Using the modified triangulation technique, a single sheath was used to access the stone from the most suitable location. Then, serial dilatation up to 30 Fr was performed with fascial dilators. A 30 Fr Amplatz sheath was placed, and access to the kidney was achieved with a 22 Fr nephroscope (Olympus, Hamburg, Germany). Stone fragmentation was performed with a pneumatic lithotripter (Vibrolith, Elmed Medical Systems). The stone fragments were removed using forceps if necessary. A postoperative 18/20 Fr re-entry malecot nephrostomy tube was placed and removed on the third postoperative day if there was no significant bleeding.

Statistical Analysis

Descriptive statistics, such as the mean, standard deviation, median, minimum, and maximum values, were used to describe the variables in the data analysis. Frequency and percentage values were used to characterize the categorical variables. The Student's t-test was used to compare the means of two independent groups. Paired t-tests were used to compare the means of two repeated measures (pre-post). Chi-square test statistics were used to assess the association between categorical variables. The level for statistical significance was established at $p < 0.05$. Data analysis was performed using SPSS version 29 (IBM, Armonk, NY, USA) statistical software.

Results

The study included 201 PCNL and 163 recurrent RIRS cases. Of the recurrent RIRS cases, 148 (90.8%) underwent 2 operations, 10 (6.1%) underwent 3 operations, 4 (2.5%) underwent 4 operations, and 1 (0.6%) underwent 5 operations. The

demographic and operative findings of the patients were statistically similar ($p > 0.05$) (Table 1).

In a comparison of mean values of PCNL and multiple RIRS cases, postoperative creatinine increased compared to preoperative measurement, while eGFR decreased. It was observed that 6 (3.0%) of the patients who underwent PCNL and 3 (1.8%) of the patients who underwent RIRS developed stage 1 AKI within 48 hours postoperatively. In PCNL cases, the increase in creatinine and the drop in eGFR were higher than in RIRS cases, but no statistically significant differences were observed ($p = 0.054$ and $p = 0.057$, respectively) (Table 2).

Discussion

This research aimed to examine the effects of recurrent RIRS and single-session PCNL on AKI within 48 hours postoperatively. Our data demonstrate that although both treatments result in alterations in renal function, the difference in AKI incidence across the groups was not statistically significant. Nonetheless,

Table 1. Comparison of the demographic and operative data of the PCNL and RIRS cases

n	PCNL	Multiple RIRS	p
	201	163	
Age (mean ± SD)	53.2±12.3	51.2±12.6	0.251
Gender (n, %)			
Male	134 (66.7%)	39 (61.9%)	0.544
Female	67 (33.3%)	24 (38.1%)	
Surgical side (n, %)			
Right	88 (43.8%)	27 (42.9%)	0.992
Left	113 (56.2%)	36 (57.1%)	
Diabetes mellitus (n, %)	35 (17.4%)	15 (9.2%)	0.072
Hypertension (n, %)	44 (21.9%)	26 (15.9%)	0.372
Coronary artery disease (n, %)	21 (10.4%)	9 (5.5%)	0.215
Body mass index (kg/m²) (mean ± SD)	28.5±4.7	28.0±4.3	0.811
ESL history (n, %)	39 (19.4%)	47 (28.8%)	0.159
Number of stones			
Single	123 (61.2%)	96 (58.9%)	0.768
Multiple	78 (38.8%)	67 (41.1%)	
Stone volume (mm³) (mean ± SD)	4122.5±2345.3	3665.8±1467.3	0.456
Stone localization (n, %)			
Upper calyx	11 (5.5%)	3 (1.8%)	0.053
Middle calyx	41 (20.4%)	5 (3.1%)	
Lower calyx	38 (18.9%)	29 (17.8%)	
Renal pelvis	33 (16.4%)	44 (27.0%)	
Upper ureter	30 (14.9%)	29 (17.8%)	
Multiple location	48 (23.9%)	53 (32.5%)	
Stone density (HU) (mean ± SD)	1099.3±434.6	1089.1±220.0	0.848
Operation time (min.) (mean ± SD)	98.1±42.0	82.1±28.2	0.056
PCNL: Percutaneous nephrolithotomy, RIRS: Retrograde intrarenal surgery, HU: Hounsfield units, min.: Minute, SD: Standard deviation			

PCNL: Percutaneous nephrolithotomy, RIRS: Retrograde intrarenal surgery, HU: Hounsfield units, min.: Minute, SD: Standard deviation

	PCNL	Multiple RIRS	p
Preoperative creatinine (mg/dL) (mean ± SD)	0.95±0.34	1.00±0.35	0.378
Postoperative creatinine (mg/dL) (mean ± SD)	0.96±0.33	1.06±0.32	0.054
Preoperative eGFR (mL/min) (mean ± SD)	86.1±31.6	84.2±20.5	0.551
Postoperative eGFR (mL/min) (mean ± SD)	83.3±36.5	82.3±20.5	0.179
Stage 1 AKI (n, %)	6 (3.0%)	3 (1.8%)	0.449
Increase in creatinine (mg/dL)	0.06	0.02	0.054
Drop in eGFR (mL/min)	2.83	1.71	0.057
PCNL: Percutaneous nephrolithotomy, RIRS: Retrograde intrarenal surgery, AKI: Acute kidney injury, eGFR: Estimated glomerular filtration rates, SD: Standard deviation			

there was a trend towards a greater rise in creatinine and a reduction in eGFR in the PCNL group relative to the multiple RIRS group, although the p-values were near they did not reach statistical significance. To our knowledge, this study is the first to compare this relationship in the literature.

Previous studies have shown that PCNL, owing to its invasive characteristics even with single access, may have a more significant effect on renal function than RIRS. Wollin and Preminger (6) highlighted that complications related to PCNL, particularly AKI, are often linked to variables such as hemorrhage and parenchymal damage. Research by Bayrak et al. (3) similarly revealed that PCNL may result in temporary reductions in renal function. Our investigation corroborates these findings since the PCNL group had a more pronounced deterioration in renal function relative to RIRS, although statistical significance was absent.

The incidence of AKI post-PCNL differs across recent studies, with reported rates between 4.4% and 25% (2,9-11). In our study, this rate was lower than the rate reported in the literature. This discrepancy may be ascribed to disparities in patient demographics, surgical methodologies, and the definitions of AKI used in the research. Advanced age, hypertension, diabetes mellitus, chronic renal disease, and chronic anemia increase the risk of AKI. Higher stone volume and density, staghorn calculi, multiple punctures, prolonged operational duration, and perioperative hypotension correlate with an elevated risk of AKI. Patients who have AKI after PCNL often endure extended hospitalizations and face an elevated risk of complications, including cardiovascular and neurological disorders, sepsis, and prolonged intensive care unit admissions. A portion of individuals may progress to chronic renal disease (12).

Conversely, new data indicate that repeated RIRS sessions may lead to renal damage, especially owing to extended operational

durations and elevated intrarenal pressure. Göger et al. (4) posited that AKI after RIRS is affected by variables such as the use of ureteral access sheaths and irrigation pressures. Although our analysis did not reveal a significant difference in AKI rates between the two treatments, it underscores the need for more prospective studies to accurately delineate the long-term renal effects of recurrent RIRS.

The therapeutic significance of these results pertains to informing treatment decisions for nephrolithiasis, especially in individuals with an elevated risk of renal impairment. Considering that PCNL is conventionally used for bigger calculi and RIRS is progressively utilized for same indications, even for stones larger than 2 cm, understanding the impact of these treatments on renal function is essential. Our findings indicate that both treatments pose a risk of AKI; single-session PCNL may lead to more significant abnormalities in renal function compared to recurrent RIRS. However, the absence of substantial changes highlights the need for personalized surgical decision-making considering patient comorbidities, stone attributes, and surgeon experience.

Study Limitations

Several limitations must be recognized. The retrospective design of this research presents possible biases, such as selection bias and heterogeneity in surgical procedures. We only investigated AKI during the early postoperative phase, and long-term renal outcomes were not studied. Future multicenter studies with larger sample sizes and prolonged follow-up periods are necessary to better clarify the renal consequences of these treatments. Furthermore, including other indicators of renal damage (e.g. NGAL and KIM-1) or urine output assessments would provide a more thorough comprehension of alterations in postoperative renal function.

Conclusion

Our results demonstrate that recurrent RIRS and single-session, single-access PCNL are linked to temporary alterations in renal function postoperatively, with a non-significant risk of increased AKI in the PCNL cohort. The findings underscore the need for personalized treatment approaches and emphasize the significance of meticulous preoperative monitoring to reduce renal complications. Additional research with extended follow-up and larger patient populations is essential to corroborate these findings and enhance surgical decision-making in nephrolithiasis treatment.

Ethics

Ethics Committee Approval: Tekirdağ Namık Kemal University Non-Interventional Clinical Research Ethics Committee approval was obtained (number: 2024.265.09.15, date: 24.09.2024).

Informed Consent: A written informed consent was obtained from participants (for the ones under age 18, a written informed consent was obtained from their parent/legal guardian/next of kin) to participate in the study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.F.Ş., Ç.D., S.Ş., E.C.T., F.B.T., C.M.Y., Concept: M.F.Ş., Ç.D., S.Ş., E.C.T., F.B.T., C.M.Y., Design: M.F.Ş., Ç.D., S.Ş., E.C.T., F.B.T., C.M.Y., Data Collection or Processing: M.F.Ş., Ç.D., S.Ş., E.C.T., F.B.T., C.M.Y., Analysis or Interpretation: M.F.Ş., Ç.D., S.Ş., E.C.T., F.B.T., C.M.Y., Literature Search: M.F.Ş., Ç.D., S.Ş., E.C.T., F.B.T., C.M.Y., Writing: M.F.Ş., Ç.D., S.Ş., E.C.T., F.B.T., C.M.Y.

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