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ORIGINAL ARTICLE

Analysis of factors affecting re-admission after retrograde intrarenal surgery for renal stone

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Abstract

Purpose To investigate the factors associated with hospital readmission (HR) after retrograde intrarenal surgery (RIRS) among renal stone patients.

Methods The study included patients who underwent RIRS from June 2011 to December 2017. Patients who were readmitted due to surgery-related complications were evaluated retrospectively. Patient demographics including age, medical comorbidity, body mass indices, ASA score, perioperative parameters and stone factors were compared with total cohorts. HR was defined as visits to the Emergency Room or unplanned admission within 30 days after discharge. The factors affecting HR rates were analyzed using uni- and multi-variate analyses.

Results A total of 572 patients were enrolled into the study. The mean age was 57.6 ± 14.1 years and the mean stone diameter was 13.4 ± 6.2 mm. The mean complication rate was 6.1% and the median hospitalization time was 2.1 ± 3.4 days. HR occurred in 20 patients (3.5%). Compared to non-admission patients, readmitted patients had a higher rate of bilateral RIRS (20.0% vs 12.2%, $p = 0.035$), number of stones (4.65 vs 2.2, $p = 0.041$) and higher stone complexity score (4.15 vs 2.11, $p = 0.003$). Multivariate analysis showed bilateral RIRS (OR 1.091, $p = 0.031$) and stone complexity (OR 1.405, $p = 0.003$) were significant factors to predict re-admission after RIRS.

Conclusion Patients with complex renal stones or those who underwent bilateral RIRS were more likely to have a higher rate of re-admission. Proper perioperative management to prevent complications should be planned based on these predictive factors.

Keywords Retrograde intrarenal surgery · Hospital readmission · Renal stone · Risk factor

Abbreviations

ESWL	Extracorporeal shock wave lithotripsy
PCNL	Percutaneous nephrolithotomy
RIRS	Retrograde intrarenal surgery
SFR	Stone-free rates
HR	Hospital readmission
ER	Emergency room
S-ReSc	Seoul National University Renal Stone Complexity score
ASA	American Society of Anesthesiologists
BMI	Body mass index
OR	Odds ratio
URS	Ureteroscopy
UTI	Urinary tract infection

Introduction

The management of renal stones has radically evolved over the last years. Extracorporeal shock wave lithotripsy (SWL) and percutaneous nephrolithotomy (PCNL) were the preferred treatment modalities for renal calculi. However, due to the advances in endoscopic flexible technology, retrograde intrarenal surgery (RIRS) has become one of the most common endourologic procedures and represents the standard for the treatment of renal stones [1]. RIRS has gained

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acceptance as a first-line alternative treatment option for renal stones, especially those up to 20 mm [2].

Due to these technological advances, RIRS has higher stone-free rates (SFR) than SWL and lower morbidity rates compared to PCNL [3, 4]. Nevertheless, RIRS is associated with complications such as pain, urinary tract infection (UTI), sepsis, re-admissions and prolonged hospitalization [5]. Hospital readmission (HR) after renal stone surgery is an unwanted condition by both the patient and the physician [6]. Symptomatic relief and reasonable SFR with RIRS are possible, reducing morbidity and hospital stay. After various endourological treatments such as SWL, PNL or RIRS, readmission rates range from 5 to 15% [6, 8, 13, 14]. HR or ER visits after surgery are considered to be negative indicators of healthcare quality and are associated with significant economic burdens. In 2010, the USA spent $17.5 billion on HR rates [7], making it essential to minimize these events.

Although the overall complications of RIRS have been well documented, studies focusing on the frequency of HR and unplanned care or factors potentially predictive of readmission after urological surgical procedures are still ongoing [8–16]. In this study, we investigated patient- and procedure-related factors that determined the rate of readmissions after RIRS. Studying such factors may result in determining patients at risk for rehospitalization after RIRS and prospective strategies to prevent such return visits.

Patients and methods

A retrospective analysis of 572 patients with renal stones treated via RIRS in a tertiary referral center was performed between June 2011 and December 2017. Unexpected visits to the hospital due to any reason related to the RIRS procedure were examined. We defined hospital readmission as visits to the ER or unplanned admission within 30 days after discharge. All patients underwent preoperative CT scans for nephrolithiasis evaluation, and stone complexity was defined by the modified S-ReSC [17]. Jeong et al. devised the Seoul National University Renal Stone Complexity (S-ReSC) score for the prediction of SFR after endoscopic stone surgery. The S-ReSC score is calculated by counting the number of sites involved in the renal pelvis and calyces, regardless of stone parameters or renal anatomy. The system assigns a score from 1 to 9 depending on the number of sites involved; the renal pelvis (1), superior and inferior major calyces (2–3), anterior and posterior minor calyces of the superior (4–5), middle (6–7), and inferior calyces (8–9) [17].

The study evaluated patient demographics which included age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) score, stone size and S-ReSC score. Anatomic abnormalities and comorbidities were recorded in a database along with operative factors variables such as operative time, duration of hospitalization, operative success or failure, and complications. Complications were classified using the Clavien–Dindo classification system [18].

Surgeons experienced in endourological methods performed all RIRS procedures. The patients were put under general anesthesia with prophylactic antibiotics administered on induction. With the patient in the lithotomic position, a semi-rigid ureteroscopy was usually performed to place a semi-stiff guidewire and to actively dilate the ureter. A safety guidewire is inserted up to the renal pelvis and access sheath insertion (Flexor ureteral access sheath 12F/14F 35 cm; Cook Medical, Bloomington, IN) is done. Flexible pyeloscopy was performed with the URF-P5 (Olympus, Tokyo, Japan) ureteroscope. The operative time commenced at the time of cystoscopy insertion and ended with the insertion of the ureteral stent. For stone fragmentation, a 200- or 365-µm laser fiber and Ho: YAG laser (OmniPulse, 20W, Trimedyne Inc., Irvine, USA) were used at an energy level of 1 J and a rate of 10 Hz; it was applied to fragment stones into pieces < 4 mm in its largest diameter. Larger stone fragments were extracted with a nitinol basket (NGage Nitinol stone extractor 2,2F 115 cm basket; Cook Medical). Intraoperative success was defined as extraction of all stone fragments or laser lithotripsy of all stones to < 4-mm fragments. A pigtail, double J ureteral catheter (DJ) was applied at the end of the procedure according to surgeon preference. Patients with uneventful postoperative complications were discharged at postoperative day 1 with antibiotics (for 3 days) and analgesics treatment. Double J stents were removed in 1–2 weeks in all patients. Stone-free status was defined as the absence of any residual fragments and/or the presence of asymptomatic fragments < 4 mm on plain imaging, and/or computed tomography 4 weeks after surgery.

Data collections were performed using the IBM SPSS version 20.0 (IBM Inc., Chicago, IL, USA). Numerical variables are shown as means with standard deviations and categorical variables as numbers with percentages. Patient demographics and operative characteristics were compared with Chi-square and Mann–Whitney *U* tests. Multiple binary logistic regressions were used to identify independent predictors of HRs and ER within 30 days. A p value < 0.05 was considered statistically significant.

Results

A total of 572 patients were enrolled in this study. The number of male patients was 308 (53.9%). The mean patient age was 57.6 ± 14.1 years and mean patient BMI was 24.4 ± 3.6 kg/m^2. The mean S-ReSC score was 2.2 ± 1.7. Preoperative ureteral stenting was done in 376 patients (65.7%), while postoperative ureteral stenting was done in 563 patients (98.5%). The mean preoperative ureteral

stenting duration was 7.2 (±3.7) days. When compared to the non-stented group, the preoperative stented group showed no significant differences in operative time (75.6 and 82.4 min, $p=0.280$), SFR (79.1 and 81.0%, $p=0.433$), and other perioperative complication rates (12.1 and 6.0%, $p=0.061$). The rate of intraoperative ureteral dilation was significantly higher in the non-stent group (9.3%) when compared to the preoperative stent group (6.0%, $p<0.001$). Although there were no statistical differences in the rate of ureteral injuries (7.0, 2.8%, respectively, $p=0.123$), 9 of 10 grade II ureteral injuries along with a grade IV ureteral injury occurred in the non-stented group.

Overall, RIRS-related hospital readmission occurred in 20 patients (3.5%). Residual stones were found in 130 patients (22.7%). The ASA scores were I in 232 patients (40.6%), II in 300 (52.4%), and III in 40 patients (7%). The maximum stone diameter was 13.4 ± 6.2 mm. Given the operative outcomes, RIRS procedures were completed with an average duration of 89.4 ± 55.9 min. The demographic features and stone characteristics of all patients are summarized in Table 1. Perioperative complications occurred at a rate of 6.1% in the patient population, while the average length of hospital stays was 2.1 ± 3.4 days. Compared with non-readmission patients ($n=552$), readmission patients ($n=20$) had a higher mean S-ReSC score (4.15 vs. 2.11, $p<0.003$), a higher rate of perioperative complications (5.7% vs 20.0%, $p=0.011$) and a higher rate of residual stones (20.9% vs 55.0%, $p<0.001$).

After discharged from the hospital, 20 (3.5%) patients were readmitted (Table 2). Of all 20 readmitted patients, the most common diagnoses were renal colic (55%), fever (30%), and postoperative hematuria (5%). Sixteen (80%) of the readmission patients had ureteral stent insertion during readmission. Of the 6 readmitted patients with postoperative fever, three patients (50%) were without ureteral stents. Two of 11(18%) the renal colic patients were without DJ stents when readmitted to our department. Two patients underwent reoperation for remnant stones. The first patient underwent second-look operation and repositioning of the ureteral catheter due to persisting hydronephrosis and the second patient had staged surgery for remaining stones in the lower pole of the kidney and duplicate ureter. Except for the two reoperation cases, all postoperative fever and renal colic cases were medically treated with analgesics and antipyretics.

To assess factors for unplanned readmission after RIRS, readmitted patients ($n=20$) were compared to patients without complications ($n=552$). On univariate analysis, the unplanned readmission rate was statistically associated

Table 1 Patient demographics

Parameters	Overall	Readmission	Non-readmission	*p* value
Number	572	20	552	
Age (years)	57.6 ± 14.1	54.9 ± 18.8	57.7 ± 13.84	0.513
Sex, male (%)	308 (53.9)	11 (55.0)	297 (53.8)	0.492
BMI (kg/m^2)	24.4 ± 3.6	23.6 ± 2.5	24.5 ± 3.7	0.261
ASA score (%)				0.252
1	232 (40.6)	11 (55.0)	221 (39.9)	
2	300 (52.4)	9 (45.0)	291 (52.7)	
3	40 (7.0)	0 (0.0)	40 (7.3)	
Comorbidity rate (%)	258 (45.1)	6 (30.0)	252 (45.7)	0.170
Laterality (%)				0.308
Unilateral	501 (87.6)	16 (80.0)	485 (87.8)	
Bilateral	71 (12.4)	4 (20.0)	67 (12.2)	
Maximal stone size (mm)	13.4 ± 6.2	12.1 ± 4.9	13.5 ± 6.2	0.350
Number of stones	2.3 ± 2.3	4.65 ± 5.0	2.2 ± 2.0	0.041
Mean S-ReSC score	2.21 + 1.76	4.15 + 2.68	2.11 ± 1.65	0.003
Modified S-ReSC (%)				
1–2	397 (68.6)	7 (35.0)	390 (70.7)	
3–4	115 (20.4)	6 (30.0)	109 (19.8)	
5–12	60 (10.8)	7 (35.0)	53 (9.5)	
Operative time (min)	89.4 ± 55.9	84.8 ± 39.1	89.7 ± 56.7	0.700
Perioperative complications (%)	35 (6.1)	4 (20.0)	31 (5.7)	0.011
Length of hospital stay (days)	2.1 ± 3.4	6.0 ± 10.6	1.8 ± 2.4	0.099
Residual stone (%)	130 (22.7)	11 (55.0)	119 (20.9)	0.000

BMI body mass index, *ASA* American Society of Anesthesiologists, *S-ReSC* Seoul National University Renal Stone Complexity score

Table 2 Categorization of perioperative complications

Clavien Dindo classification	Complication	Number of patients
Clavien Grade I		
	Fever	6 (30%)
	Postoperative hematuria	1 (5%)
Clavien Grade II		
	Renal Colic	11 (55%)
Clavien Grade IIIA		
Clavien Grade IIIB		
	Reoperation	2 (10%)
Clavien Grade IV		0
Total		20

with the modified S-ReSC score, comorbidity, bilateral RIRS, and residual stones (Table 3). (All $p < 0.05$) On multivariate analysis, stone complexity (OR 1.40, $p = 0.003$), and bilateral RIRS (OR 1.09, $p = 0.031$) increased the risk of readmission. Meanwhile, the modified S-ReSC score was the most significant independent predictor of RIRS-related readmission (Table 3).

Discussion

As the prevalence of kidney stones increases, readmission and postsurgical ER visits are of increasing concern to the urologist and the patients who underwent urolithiasis [19, 20].

An unwanted visit to the ER or readmission is a significant event and can negatively affect both the quality of life and financial burden of the patient. To our knowledge, there are several studies that have reflected this area regarding the potential predictive factors after urological procedures [8–16].

Rambachan et al. [8] reported readmission after outpatient urological surgery occurred at a rate of 3.7% using a national database system. The study concluded that male gender, history of cancer, bleeding disorders, ASA III and IV were associated with readmissions. However, the study did not have adequate data on stone disease that was possibly associated with higher rates of readmission. In a recently published study, Scales et al. [6] investigated HR rate following SWL, ureteroscopy (URS) and PCNL using data from the market scan. According to the study, SWL has the lowest unplanned visit rate (12%) compared to URS (15%) and PCNL (15%). The study showed that facility volume and comorbidity scores were found to be related to unplanned visit following SWL, URS, and PCNL procedures.

In another study, Beiko et al. [11] reported the outcome of ambulatory PCNL patients, which included the assessment of ER visits and postoperative readmissions. The authors noted a rate of 12% for returning to ER and 4% for readmission rate. In a previous study that analyzed a PCNL database from the UK, it showed that PCNL patients had a readmission rate of 9.0% and a rate of 0.2% regarding in-hospital deaths within 30 days of surgery regarding their primary outcomes [9]. In this study, the post RIRS readmission rate was 3.5%. While the majority of the rehospitalized cases were treated medically, only 2 cases needed intervention. This rate may be due to the minimal invasive nature of RIRS compared to other procedures.

This study was done to identify the patient and perioperative factors that may increase the risk of HRs and rehospitalization after RIRS. We included perioperative parameters such as comorbidity, stone complexity, bilateral RIRS, and the length of the operation. In our analysis, residual stone was associated with a higher risk of readmission. A recent report concluded that the presence of stone residual after SWL, PCNL, or RIRS is associated

Table 3 Multivariate logistic regression analysis to predict factors for hospital readmission after retrograde intrarenal surgery

Parameters	Univariate		Multivariate	
	OR (95% CI)	*p*	OR (95% CI)	*p*
Age	0.986 (0.955–1.018)	0.382		
Male	0.687 (0.278–1.698)	0.416		
BMI	0.928 (0.816–1.056)	0.259		
Comorbidity	0.510 (0.192–1.357)	0.178		
Bilateral RIRS	1.138 (1.058–1.224)	0.001	1.091 (1.008–1.180)	0.031
Maximal stone size	0.960 (0.882–1.045)	0.347		
Modified S-ReSC	1.572 (1.288–1.920)	< 0.001	1.405 (1.121–1.760)	0.003
Operative time	0.998 (0.989–1.007)	0.699		
Residual stone	4.619 (1.848–11.545)	0.001	2.187 (0.746–6.411)	0.154

BMI body mass index, *RIRS* retrograde intrarenal surgery, *S-ReSc* Seoul National University Renal Stone Complexity score

with higher risk of renal colic pain, hematuria, and urinary tract infection [21]. A study done by Tepeler et al. found that postoperative PCNL re-admission and re-hospitalization rates were 5.76 and 5.27%, respectively. Moreover, independent predictors of unplanned re-admissions were anatomic abnormalities, postoperative complications, and stone complexity, while the duration of hospitalization and the presence of postoperative complications were associated with rehospitalization [22]. Similar to other reports, our series also comprised individuals who readmitted within 30 days of surgery. After multivariate analysis, bilateral RIRS and complex kidney stones were predictors of HR. The unplanned HR was 3.5% in our study which was similar to the 3–15% readmission rates of other reports [6, 8, 13, 14, 22].

With its low morbidity and the usage of natural anatomy, RIRS is accepted as the first-line treatment for urinary stones. However, complications such as sepsis and severe hemorrhage are still apparent in RIRS [5]. Breda and Angerri [23] reported that the overall complication rate for RIRS was 8% and the frequency of major complications was 1.9%. In a study done by Sabnis et al. [24] postoperative complications of Clavien Grade I occurred in 11.4% of the patients, and no other grade complication was noted. A mean complication rate of 6.1% was seen in our procedures. Postoperative renal colic was the most common complication. It occurred in 55% of readmitted patients. The usage of ureteral access sheath during RIRS, long operative times and the presence of ureteral stent all may have contributed to renal colic.

The results of this study have constructive information for urologists and patients who are undergoing RIRS. The identification of HR risk factors may improve the compliance between patient and physician, to reduce readmission rates. In addition, urologists can selectively focus on high-risk patients who require detailed management prior to discharge. Moreover, prevention of complications and proper perioperative management of may reduce the rate of readmission.

Some limitations for this study should be acknowledged. The first limitation of this study is the lack of uniform evaluation of residual fragment and stone-free rates which would result in inter-observer variability. However, even with a unified residual fragment evaluation, in the clinical standpoint, it is non-viable, since variability is common in clinical practice [25]. A second limitation would be the non-uniform treatment approach and the different experience of the surgeons. Another limit of this study is the retrospective nature and the relatively small number of re-admission patients with complications. It is likely that our study population does not adequately cover all potential variables and risk factors. Nonetheless, few studies have solely focused on this issue and we believe that this study provides insight for endourologists when counseling patients before RIRS and as a guideline for perioperative management.

Conclusion

In summary, this study demonstrates that patients, who had complex kidney stones and a history of bilateral renal stone surgery, were more likely to have an unplanned HR. Moreover, we found that patients with a history of perioperative complications also seem to have a tendency to unplanned HR and rehospitalization. Therefore, the outcomes of this study could provide endourologists with counseling and management guidelines when treating patients with complex stones and perioperative complications.

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Compliance with ethical standards

Conflict of interest All authors have no conflict of interest with any institution or product.

Ethical approval All procedures performed in our study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments.

Informed consent Informed consent was obtained from all individual participants included in the study.

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