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Stone Disease

Improving Outcomes of Same-sitting Bilateral Flexible Ureteroscopy for Renal Stones in Real-world Practice—Lessons Learnt from Global Multicenter Experience of 1250 Patients

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Abstract

Background: Bilateral kidney stones are commonly treated in staged procedures.
Objective: To evaluate outcomes after same-sitting bilateral retrograde intrarenal surgery (SSB-RIRS) for renal stones.
Design, setting, and participants: Data from adults who underwent bilateral RIRS in 21 centers were retrospectively reviewed (from January 2015 to June 2022). The inclusion criteria were unilateral/bilateral symptomatic bilateral stone(s) of any

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size/location in both kidneys and bilateral stones on follow-up with symptom/stone progression. Stone-free rate (SFR) was defined as absence of any fragment >3 mm at 3 mo.

Outcome measurements and statistical analysis: Continuous variables are presented as medians and 25–75th percentiles. A multivariable logistic regression analysis was performed to evaluate independent predictors of sepsis and bilateral SFR.

Results and limitations: A total of 1250 patients were included. The median age was 48.0 (36–61) yr. Of the patients, 58.2% were prestented. The median stone diameter was 10 mm on both sides. Multiple stones were present in 45.3% and 47.9% of the left and right kidneys, respectively. Surgery was stopped in 6.8% of cases. The median surgical time was 75.0 (55–90) min. Complications were transient fever (10.7%), fever/infection needing prolonged stay (5.5%), sepsis (2%), and blood transfusion (1.3%). Bilateral and unilateral SFRs were 73.0% and 17.4%, respectively. Female (odds ratio [OR] 2.97, 95% confidence interval [CI] 1.18–7.49, $p = 0.02$), no antibiotic prophylaxis (OR 5.99, 95% CI 2.28–15.73, $p < 0.001$), kidney anomalies (OR 5.91, 95% CI 1.96–17.94, $p < 0.001$), surgical time $\geq$100 min (OR 2.86, 95% CI 1.12–7.31, $p = 0.03$) were factors associated with sepsis. Female (OR 1.88, 95% CI 1.35–2.62, $p < 0.001$), bilateral prestenting (OR 2.16, 95% CI 1.16–7.66, $p = 0.04$), and the use of high-power holmium:YAG laser (OR 1.63, 95% CI 1.14–2.34, $p < 0.01$) and thulium fiber laser (OR 2.50, 95% CI 1.32–4.74, $p < 0.01$) were predictors of bilateral SFR. Limitations were retrospective study and no cost analysis.

Conclusions: SSB-RIRS is an effective treatment with an acceptable complication rate in selected patients with kidney stones.

Patient summary: In this large multicenter study, we looked at outcomes after same-sitting bilateral retrograde intrarenal surgery (SSB-RIRS) for renal stones in a large cohort. We found that SSB-RIRS was associated with acceptable morbidity and good stone clearance after a single session.

1. Introduction

The incidence of nephrolithiasis has increased in the last two decades, with a prevalence ranging from 7% to 13% in North America, 1% to 5% in Asia, and 5% to 9% in Europe [1]. Boyce et al [2] found that the prevalence of kidney stone disease was 1.7% in a large series of asymptomatic patients, with 10% of them having bilateral stones. Up to a third of asymptomatic stones ultimately require intervention [3], and patients with bilateral stones are at a high risk for recurrence and surgical intervention [4]. Traditionally, bilateral kidney stones have been treated in staged procedures because of concerns regarding the safety of performing same-session bilateral surgery. Nevertheless, the potential advantages of bilateral simultaneous procedures rely on single anesthesia, less utilization of disposable devices, reduced surgical time and cumulative hospital stay, and fewer working day loss with subsequent lower overall cost. In this scenario, retrograde intrarenal surgery (RIRS) is an appealing procedure due to its wide adoption [5], low morbidity [6], and excellent stone-free rate (SFR) [5]. However, only a few small, mainly single-center series studies reported the outcomes of same-sitting bilateral RIRS (SSB-RIRS) with disparity between the inferences [7–11].

This study aimed to assess the outcomes of SSB-RIRS in a large, real-life series of patients with kidney stones.

2. Patients and methods

As a part of the Team of Worldwide Endourological Researchers of the Endourological Society, a retrospective analysis of all consecutive patients who had SSB-RIRS for renal stones between January 2015 and June 2022 in 21 centers was performed. Consultant surgeons involved in this study had RIRS experience of performing >100 procedures. The inclusion criteria were age $\geq$18 yr, bilateral stones of any size and location in the kidneys diagnosed due to unilateral or bilateral symptomatic presentation, and patients with bilateral renal stones who were on follow-up and noted to have stone or symptom progression. The exclusion criteria were concomitant ureteral lithotripsy, stone located in a calyceal diverticulum, in-tandem procedure, and RIRS done as a combined procedure for endoscopic combined intrarenal surgery. Stone size was calculated as the largest diameter. In the case of multiple stones, data from the largest stone were reported. Antiplatelets/anticoagulants were stopped 3–7 d before surgery and resumed as per each center's discretion. Antibiotic prophylaxis was given in each center with a single on-table dose chosen as per the local pathogen prevalence and antibiotic susceptibility profiles. Lithotripsy was carried out either by holmium:YAG laser (HL) or by thulium fiber laser (TFL). RIRS was performed as per the current standard technique [12]. We collected the number of procedures that were ended before complete bilateral lithotripsy and the reasons behind their abortion. The decision to abandon surgery was individualized by each surgeon's own previous experience. Surgical time was estimated from the start of cystoscopy to the placement of a bladder catheter. Sepsis was defined as "life-threatening organ dysfunction caused by a dysregulated host response to infection" [13]. SFR was assessed 3 mo after surgery according to the local standard of care with

Table 1 – Patient baseline characteristics

N = 1250	
Age (yr), median (25–75th percentile)	48.0 (36.0–61.0)
Males, n (%)	844 (67.5)
Ethnicity, n (%)	
Indian	319 (25.5)
Caucasian	105 (8.4)
Middle East	117 (9.4)
Russian	93 (7.4)
North African	24 (1.9)
Asian	561 (44.9)
Turkish	31 (2.5)
Body mass index, median (25–75th percentile)	26.5 (23.0–30.0)
Comorbidity, n (%)	
Diabetes	178 (14.2)
Hypertension	373 (29.8)
On antiplatelet/anticoagulation drugs	179 (14.3)
Ischemic heart disease	159 (12.7)
Spinal deformity	35 (2.8)
Chronic kidney disease	136 (10.9)
ASA score, n (%)	
1	600 (48.0)
2	496 (39.7)
3	153 (12.2)
4	1 (0.1)
Symptoms at presentation, n (%)	
Hematuria only	147 (11.8)
Pain	748 (59.8)
Hematuria and pain	281 (22.5)
Asymptomatic	74 (5.9)
Side of pain (n = 1029)	
Right	309 (30.0)
Left	296 (28.9)
Bilateral	424 (41.1)
Emergency presentation due to ureteric stone, n (%)	225 (18)
Recurrent stone formers, n (%)	578 (46.2)
Positive urine culture at presentation, n (%)	523 (41.8)
Prestented, n (%)	
No	523 (41.8)
Unilaterally	456 (36.5)
Bilaterally	271 (21.7)
Reason for prestenting (n = 727) [a], n (%)	
Failure to access	184 (25.3)
Routine practice	234 (32.2)
Symptomatic	207 (28.5)
Emergency stenting	102 (14.0)
Prestenting days (n = 727), n (%)	
<14	282 (38.8)
≥14	445 (61.2)
Preoperative tamsulosin, n (%)	467 (37.4)
Preoperative imaging modality, n (%)	
Noncontrast CT	1090 (87.2)
Contrast CT	132 (10.6)
Combination of x-ray and ultrasound	28 (2.2)
Kidney/collecting system anatomy, n (%)	
Bilateral normal	1183 (94.7)
Unilateral malrotated	24 (1.9)
Horseshoe kidney	19 (1.5)
Unilateral duplex collecting system	19 (1.5)
Unilateral ectopic kidney	5 (0.4)
Left kidney	
Stone diameter (mm), median (25–75th percentile)	10.0 (8.0–13.0)
HU, median (25–75th percentile)	1050 (800–1300)
Multiple stones, n (%)	566 (45.3)
Stone location, n (%)	
Upper pole	222 (17.8)
Middle pole	304 (24.3)
Lower pole	347 (27.8)
Pelvis	377 (30.1)
Right kidney	
Stone diameter (mm), median (25–75th percentile)	10 (7.8–13.0)
HU, median (25–75th percentile)	1010 (800–1286)
Multiple stones, n (%)	599 (47.9)
Stone location, n (%)	
Upper pole	245 (19.6)
Middle pole	313 (25.0)
Lower pole	342 (27.4)
Pelvis	350 (28.0)

ASA = American Society of Anesthesiologists; CT = computed tomography; HU = Hounsfield units.
[a] Failure to access: failure to access the renal pelvis with ureteral access sheath due to a noncompliant ureter. Routine practice: stent insertion to allow passive ureteral dilatation before elective surgery. Symptomatic: relief of pain with delayed surgery. Emergency stenting: stent insertion due to acute renal failure/infection with delayed surgery.

kidney, ureter, and bladder x-ray and/or ultrasound or noncontrast computed tomography (CT), and was defined as absence of any residual fragment (RF) >3 mm. The study approval by the institutional review board was obtained from the Asian Institute of Nephrology and Urology (AINU #13/2022). Each center provided anonymized data and had approval from their institutional review board if deemed necessary.

2.1. *Statistical analysis*

Categorical data are presented as absolute numbers and percentages, and continuous data as medians and (25–75th percentiles). A univariate logistic regression analysis was performed to assess factors associated with sepsis and bilateral SFR. Variables significantly associated with sepsis and SFR were analyzed in a multivariable logistic regression model. Data are presented as odds ratio (OR) and 95% confidence interval (CI). Statistical significance was set at two-tailed $p < 0.05$. All statistical tests were performed using the SPSS software package version 25.0 (IBM Corp., Armonk, NY, USA).

3. Results

During the study period, 1250 patients met the inclusion criteria. Table 1 shows patient baseline characteristics. There were 844 (67.5%) males. The median age was 48.0 (36–61) yr. Pain was the most common symptom at presentation (59.8%), followed by hematuria and pain (22.5%). Almost half of the patients were recurrent stone formers (46.2%). Of the patients, 58.2% were prestented, with routine practice (32.2%) as the main. The median stone diameter was 10 mm on both sides, and the pelvis was the most common stone location in both kidneys. Multiple stones were present in 45.3% and 47.9% of the left and right kidneys, respectively.

Table 2 displays intraoperative outcomes. Antibiotic prophylaxis was administered in 84% of cases; 89.4% of patients had bilateral surgery under general anesthesia. Only 98 cases (7.8%) were performed sheathless. A ureteral access sheath (UAS) was employed bilaterally in most of the cases (72.6%). A reusable ureteroscope was used in 56.9% of cases. Low-power HL was used in 41.4% of cases, followed by high-power HL (33.2%) and TFL (24.4%). A combination of techniques was the most common lithotripsy mode (71%). Surgery was stopped in only 85 (6.8%) cases, and the most

Table 2 – Intraoperative outcomes

N = 1250	
Preoperative antibiotics given for, *n* (%)	
Urinary tract infection	137 (11.0)
Prophylaxis	1050 (84.0)
No antibiotics	63 (5.0)
Anesthesia, *n* (%)	
General	1118 (89.4)
Gated	402 (36.0)
Apneic	273 (24.4)
None	443 (39.6)
Spinal	132 (10.6)
Semirigid ureteroscopy before RIRS, *n* (%)	1008 (80.6)
Patient position, *n* (%)	
Split leg	20 (1.6)
Lithotomic	1230 (94.8)
Surgeon position, *n* (%)	
Sitting	825 (66.0)
Standing	384 (30.7)
Missing	41 (3.3)
Multiple surgeons involved in the procedure, *n* (%)	204 (16.3)
Procedure done by, *n* (%)	
Consultant	1031 (82.5)
Trainer	22 (1.8)
Both	197 (15.8)
UAS, French (outer diameter), *n* (%)	
Sheath less	98 (7.8)
10	224 (17.9)
10.5	223 (17.8)
12	372 (29.8)
13	108 (8.6)
14	116 (9.3)
Missing	109 (8.8)
Suction UAS, *n* (%)	171 (13.7)
Bilateral UAS (*n* = 1152), *n* (%)	836 (72.6)
Same UAS (*n* = 1152), *n* (%)	947 (82.2)
Type of ureteroscopes, *n* (%)	
Single use	539 (43.1)
Reusable	711 (56.9)
Size of ureteroscope tip, French, *n* (%)	
7.5	588 (47.0)
7.6	18 (1.4)
7.7	398 (31.8)
8.0	10 (0.8)
8.4	5 (0.4)
8.5	102 (8.2)
8.6	14 (1.1)
9.0	3 (0.2)
9.5	104 (8.3)
Missing	8 (0.6)
Scope breakage needing change, *n* (%)	20 (1.6)
Type of laser, *n* (%)	
Holmium laser ≤30 W	517 (41.4)
Holmium laser >30 W	415 (33.2)
Thulium fiber laser	318 (25.4)
MOSES technology	151 (12.1)
Lithotripsy mode, *n* (%)	
Dusting	439 (35.1)
Fragmentation	232 (18.6)
Pop corning	195 (15.6)
Combination [a]	888 (71.0)
Fragment extraction by basket, *n* (%)	566 (45.3)
Postoperative stent positioning, *n* (%)	1216 (97.3)
Bilaterally (*n* = 1216)	710 (58.4)
Reasons for postoperative stent positioning (*n* = 1216), *n* (%)	
Routine practice	1078 (86.2)
Possible reintervention	124 (9.9)
Ureteric injury	32 (2.6)
Missing	34 (2.7)
Intraoperative complications, *n* (%)	
Pelvicalyceal system injury	16 (1.3), bilateral in 11
Ureteric injury	32 (2.6)
Bilateral injury	1 (0.08)
Traxer grade 1	20 (1.6)
Traxer grade 2	12 (0.9)
Need to stop surgery, *n* (%)	85 (6.8)
Reasons to stop surgery (*n* = 85) [b]	
Anesthesia issue	16 (18.8)
Prolonged operation time	50 (58.8)
Scope breakdown	3 (3.5)
Surgeon decision	68 (80.0)
Stone volume deemed too big	29 (34.2)
Concern for sepsis	37 (43.5)
Total fluoroscopy time (s), median (25–75th percentile)	78.0 (48.0–120.0)
Lasing time (min), median (25–75th percentile)	36.0 (30.0–50.0)
Total surgical time (min), median (25–75th percentile)	75.0 (55.0–90.0)
On-table estimated SFR, *n* (%)	801 (64.1)

RIRS = retrograde intrarenal surgery; SFR = stone-free rate; UAS = ureteral access sheath.
[a] Combination of two or three modes.
[b] More than one choice possible.

reported reason was prolonged operation time (58.8%) followed by concern for sepsis (43.5%). Most patients had a stent positioned after RIRS (97.3%, bilaterally in 58.4% of patients). The median fluoroscopic time was 78.0 (48–120) s. The median surgical time was 75.0 (55–90) mi (90 [62–125] min in those patients who had their surgery stopped vs 74 [55–90] min in those whose surgery was completed bilaterally).

Regarding early postoperative complications (Table 3), 134 (10.7%) patients had fever lasting up to 24 h (Clavien 1), 69 (5.5%) had fever/infection needing prolonged stay (Clavien 2), 25 (2%) had sepsis requiring intensive care admission (Clavien 4b), and 16 (1.3%) required a blood transfusion (Clavien 2). The median hospital stay was 2 (1–2) d, and 241 (14.3%) patients were discharged within 24 h of surgery.

At 3-mo follow-up, bilateral SFR was 73.0%, whereas unilateral SFR was 17.4%. Among 338 patients with RF, 189 (55.9%) were deemed suitable for observation only. RIRS was the most preferred option in those requiring further treatment (37%).

Female (OR 2.97, 95% CI 1.18–7.49, p = 0.02), no antibiotic prophylaxis (OR 5.99, 95% CI 2.28–15.73, p < 0.001), kidney anomalies (OR 5.91, 95% CI 1.96–17.94, p < 0.001), and surgical time ≥100 min (OR 2.86, 95% CI 1.12–7.31, p = 0.03) were factors associated with sepsis at the multivariable analysis (Table 4). Female (OR 1.88, 95% CI 1.35–2.62, p < 0.001), bilateral prestenting (OR 2.16, 95% CI 1.16–7.66, p = 0.04), and the use of high-power HL (OR 1.63, 95% CI 1.14–2.34, p < 0.01) and TFL (OR 2.50, 95% CI 1.32–4.74, p < 0.01) were predictors of bilateral SFR at the multivariable analysis (Table 5), whereas age (OR 0.98, 95% CI 0.97–0.99, p < 0.001), stone size (OR 0.94, 95% CI 0.93–0.98, p < 0.01 in the left kidney; OR 0.96, 95% CI 0.94–0.99, p < 0.01 in the right kidney), and surgical time ≥100 min (OR 0.38, 95% CI 0.26–0.58, p < 0.001) were less likely associated with bilateral SFR.

4. Discussion

Bilateral renal stones pose a unique challenge for patients and surgeons alike, and while there are no guidelines on

Table 3 – Postoperative outcomes

N = 1250	
30-d postoperative complications, n (%)	
Fever >38°C lasting up to 24 h	134 (10.7)
Fever/infection needing prolonged stay	69 (5.5)
Sepsis requiring ICU admission	25 (2.0)
Hematuria with dropped hemoglobin	90 (7.2)
Blood transfusion	16 (1.3)
Stone analysis (n = 1045) [a], n (%)	
Calcium oxalate monohydrate	479 (45.8)
Calcium oxalate dihydrate	311 (29.8)
Uric acid	109 (10.5)
Struvite	90 (8.6)
Cystine	19 (1.8)
Carbonate calcium phosphate	14 (1.3)
Hydroxyapatite	13 (1.2)
Brushite	5 (0.5)
Mixed	5 (0.5)
Hospital stay (<24 h), n (%)	241 (14.3)
Hospital stay (d), median (25–75th percentile)	2 (1–2)
Post-RIRS imaging within 48 h, n (%)	763 (61.0)
Noncontrast CT	102 (13.4)
X-ray	381 (49.8)
Ultrasound	263 (34.5)
Combination of x-ray and ultrasound	17 (2.3)
Post-RIRS imaging at 3 mo, n (%)	1206 (96.5)
Noncontrast CT	612 (50.8)
X-ray	292 (24.2)
Ultrasound	168 (13.9)
Combination of x-ray and ultrasound	134 (11.1)
RF single >3 mm, n (%)	
Unilateral	132 (10.6)
Bilateral	52 (4.2)
Multiple RF any size, n (%)	
Unilateral	86 (6.9)
Bilateral	92 (7.4)
SFR, n (%)	
Unilateral	218 (17.4)
Bilateral	912 (73.0)
Bilateral non–stone free	120 (9.6)
Post-RIRS procedures for RF (n = 338), n (%)	
ESWL	18 (5.3)
RIRS	125 (37.0)
PCNL	1 (0.3)
ECIRS	5 (1.5)
Observe	189 (55.9)

CT = computed tomography; ECIRS = endoscopic combined intrarenal surgery; ESWL = extracorporeal shock wave lithotripsy; ICU = intensive care unit; PCNL = percutaneous nephrolithotomy; RF = residual fragments; RIRS = retrograde intrarenal surgery; SFR = stone-free rate.
[a] Number of stones analyzed.

the best approach, in recent times RIRS has made the management of these stones more accessible. In fact, current endourological intervention for kidney stone disease is so advanced that endoscopic combined intrarenal surgery and simultaneous bilateral endoscopic surgery are now considered the forerunners for a tailored and personalized approach in managing such patients [14,15]. However, large-volume multicenter real-world data are lacking on how bilateral surgical intervention by RIRS impacts SFR and surgical complications. This study highlights the pre-, intra-, and postoperative nuances; considerations; and outcomes of SSB-RIRS from a global perspective.

First, the indication for bilateral surgery should be evaluated. Almost all patients included in our analysis were symptomatic at presentation (95.1%), and most of them presented with pain (82.3%). Among the latter, the pain was bilateral in 41.1%. Traditional teaching advocates renal stone intervention for symptomatic patients and possible observation for the asymptomatic side. For patients with asymptomatic stones, in certain situations intervention may be approached. Despite RIRS having a good track record of being a safe and effective minimally invasive intervention [5], many surgeons hesitate to perform bilateral RIRS as theoretically it can double the complications and may not give the desired SFR [7].

Nevertheless, treating both sides is also advisable in patients with a concurrent asymptomatic contralateral stone, given that it is done under the same anesthesia as a single-session procedure. Indeed, Li et al [16] demonstrated that patients with contralateral stones >6 mm were more likely to require forthcoming surgery than those treated bilaterally. Geraghty et al [3] showed that evidence for bilateral simultaneous endourological procedures is limited, but results showed that outcomes are at least equivalent to staged procedures. The key advantages seem to be reduced operative time, cost, and hospital stay. Perhaps our study reflects this trend of offering upfront intervention in asymptomatic and symptomatic sides with RIRS under one anesthesia to benefit the patient and prevent the need for subsequent intervention.

On the contrary, one can argue that the complication rate might be higher after SSB-RIRS compared with unilateral/staged procedures. Danilovic et al [7] compared the outcomes of SSB-RIRS with unilateral procedures and found that the former had significantly more overall complications (15.9% vs 39.9%) and emergency room admissions (11.6% vs 34.8%) than the latter. However, that study was biased by the fact that bilateral surgery was compared with single-side-only procedures and not with the number of renal units treated. In fact, the risk of complications is distributed over time in staged treatment than being encountered at once in SSB-RIRS [17]. Peng et al [8] matched bilateral with unilateral RIRS based on overall renal units and demonstrated that the complication rate did not differ significantly.

Among RIRS complications, sepsis is undoubtedly the most dreadful one, being associated with extended hospitalization, intensive care unit admission, and even death. In our series, the incidence of sepsis was 2%, and this was in line with a recent review that found its incidence to range from 0.5% to 11% in unilateral surgery [18]. We found that women were at an almost three-fold higher risk of sepsis, and this should be acknowledged when one counsels patients before a planned SSB-RIRS.

The presence of kidney anomalies was found to be another sepsis risk factor in our series. This is perhaps related to renal/collecting system anatomy, which often results in compromised urine drainage and increases the risk of developing urinary tract infections. A previous study by García Rojo et al [19] showed that the incidence of post-RIRS sepsis in anomalous kidneys was 10.1%, confirming that renal/collecting system anomalies are more prone to infections. Patients with anomalous kidneys were not excluded from our analysis if they had bilateral RIRS, as ours was a real-life study and we were interested in evaluating the outcomes in such a case. Indeed, RIRS showed to be safe

Table 4 – Univariable and multivariable analysis of factors affecting sepsis

	Univariable analysis		Multivariable analysis	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Age	1.01 (0.98–1.03)	0.7	–	
Female	2.71 (1.22–6.0)	**0.01**	2.97 (1.18–7.49)	**0.02**
ASA score	1.37 (0.80–2.36)	0.26	–	
Body mass index	0.94 (0.71–1.24)	0.63	–	
Diabetes	1.15 (0.39–3.39)	0.80	–	
Chronic kidney disease	1.4 (0.47–4.14)	0.54	–	
Positive urine culture	2.12 (0.94–4.75)	0.69	–	
Prestenting				
No prestenting	0.56 (0.07–4.67)	0.59		
Unilateral	1.76 (0.66–4.74)	0.26		
Bilateral	1.48 (0.47–4.62)	0.51	–	
Antibiotics (ref. prophylaxis)				
Treating urinary tract infections	2.42 (0.54–10.92)	0.25	–	
No antibiotics	5.2 (2.21–12.26)	**<0.001**	5.99 (2.28–15.73)	**<0.001**
Kidney anomalies (ref. normal bilateral kidneys)	4.70 (1.71–12.91)	**<0.01**	5.91 (1.96-17.94)	**<0.01**
Recurrent stone formers	1.27 (0.57–2.80)	0.56		
Left kidney stone size	1.05 (0.98–1.14)	0.14	–	
Left kidney Hounsfield units	1.00 (0.99–1.01)	0.2	–	
Multiple left kidney stone	1.81 (0.81–4.06)	0.15	–	
Right kidney stone size	1.02 (0.95–1.10)	0.53	–	
Right kidney Hounsfield Units	1.00 (0.99–1.00)	0.720	–	
Multiple right kidney stone	1.94 (0.85–4.43)	0.16	–	
No ureteral access sheath	1.05 (0.23–4.32)	0.99	–	
Ureteral access sheath less than 12 French	0.25 (0.03–1.98)	0.12		
Type of laser (ref. low power holmium)				
High-power holmium	0.35 (0.11–1.70)	0.07		
Thulium fiber laser	0.81 (0.32–2.03)	0.65	–	
Lithotripsy mode (ref. pop-corning)				
Dusting	0.68 (0.24–1.95)	0.47		
Fragmentation	0.66 (0.18–2.36)	0.52		
Combination	0.94 (0.32–2.82)	0.92	–	
Disposable ureteroscope	1.22 (0.55–2.70)	0.62		
Ureteroscope tip >8 French	1.77 (0.73–4.28)	0.21		
Lasing time	1.01 (0.98–1.04)	0.42	–	
Surgical time ≥100 min (ref. <100 min)	2.95 (1.21–7.21)	**0.02**	2.86 (1.12–7.31)	**0.03**
Bilateral residual fragments	1.23 (0.29–5.27)	0.78	–	
Mixed stones	1.32 (0.76–3.50)	0.72		
Brushite stones	0.88 (0.23–2.95)	0.89		
Hydroxyapatite stones	6.34 (0.76–52.69)	0.08		
Uric acid stones	0.91 (0.21–3.91)	0.88		
Cystine stones	6.18 (1.35–28.31)	**0.01**	8.62 (0.97–32.12)	0.10
Calcium oxalate monohydrate stones	0.75 (0.32–1.76)	0.51		
Calcium oxalate dihydrate stones	1.43 (0.61–3.35)	0.41		
Struvite stones	1.53 (0.07–3.98)	0.54		
Carbonate calcium phosphate	0.97 (0.42–3.12)	0.76		

ASA = American Society of Anesthesiologists; CI = confidence interval; OR = odds ratio; ref = reference.
Bold value stands for significant *p* value.

and effective with high single-stage SFR and a low complication rate [19].

According to the current European Association of Urology guidelines, antibiotic prophylaxis should be offered to all patients undergoing endourological treatment [20]. In our series, patients who had no prophylaxis demonstrated a six-fold higher risk of sepsis, undoubtedly demonstrating the importance of prophylaxis in reducing the risk of serious infective complications after SSB-RIRS.

Surgical time is another pivotal factor associated with sepsis following RIRS [18]. Ozgor et al [21] demonstrated that RIRS lasting for >60 min was associated with a doubled risk of infectious complications. Yet, Sugihara et al [22] showed a linear positive association between operation time and severe adverse events (OR 1.58 in 90–119 min; OR 4.28 in >210 min compared with ≤59 min) [22]. Our analysis reflects that when the surgical time lasted for >100 min, there was a 2.8-fold higher risk of sepsis. Longer operative time especially without a UAS can cause deleterious complications related to persistently high intrarenal pressure, which can lead to pyelorenal backflow with the concomitant entrance of pathogens and endotoxins into the blood stream [23]. In our series, we employed a small-diameter UAS (≤12 French) in 65.5% of cases and ureteroscopes with a small-sized tip (≤7.7 French) in 80.2% of cases, which allowed a good outflow, and as a consequence, an acceptable rate of infectious complications, and a very low rate of ureteric injury. The utility of these for SSB-RIRS reflects that in modern-day RIRS practice, surgeons preferably choose smaller-diameter scopes and UAS to minimize the possibility of any ureteric injury [24].

A 100-min cutoff could be a reasonable time to reduce the risk of sepsis SSB-RIRS, and urologists should not exceed it to render patients stone free. As a matter of fact, in some circumstances, we decided to stop surgery earlier due to concerns for sepsis or prolonged operation time. Therefore,

Table 5 – Univariable and multivariable analysis of factors affecting bilateral stone-free rate

	Univariable analysis		Multivariable analysis	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Age	0.97 (0.96–0.98)	**<0.001**	0.98 (0.97–0.99)	**<0.001**
Female	0.60 (0.46–0.78)	**<0.001**	1.88 (1.35–2.62)	**<0.001**
Body mass index	0.94 (0.87–1.01)	0.05	–	
Prestenting (ref. no prestenting)				
Unilateral	1.61 (1.19–2.17)	**0.02**	1.35 (0.66–1.59)	0.51
Bilateral	9.19 (3.94–21.46)	**<0.001**	2.16 (1.16–7.66)	**0.04**
Kidney anomalies (ref. normal bilateral kidneys)	0.60 (0.36–1.01)	0.05	–	
Recurrent stone formers	0.61 (0.47–0.78)	**<0.001**	0.82 (0.59–1.12)	0.21
Left kidney stone size	0.93 (0.91–0.95)	**<0.001**	0.94 (0.93–0.98)	**<0.01**
Left kidney upper pole	0.69 (0.47–1.02)	0.06	–	
Left kidney middle pole	0.92 (0.66–1.27)	0.6	–	
Left kidney lower pole stone	1.18 (0.87–1.60)	0.28	–	
Left kidney renal pelvis	1.75 (1.31–2.33)	**<0.001**	1.34 (0.91–1.01)	0.15
Left kidney Hounsfield units	1.02 (0.99–1.01)	0.05	–	
Multiple left kidney stones	0.56 (0.45–0.74)	**<0.001**	1.14 (0.77–1. 70)	0.51
Right kidney stone size	0.91 (0.88–0.93)	**<0.001**	0.96 (0.94–0.99)	**<0.01**
Right kidney upper pole	1.31 (0.89–1.92)	0.17	–	
Right kidney middle pole	0.88 (0.72–1.17)	0.51	–	
Right kidney lower pole stone	1.02 (0.75–1.39)	0.88	–	
Right kidney renal pelvis	1.73 (1.29–2.33)	**<0.001**	0.84 (0.56–1.26)	0.39
Right kidney Hounsfield units	1.03 (0.96–1.11)	0.23	–	
Multiple right kidney stones	0.55 (0.42–0.71)	**<0.001**	0.88 (0.60–1.31)	0.53
No ureteral access sheath	1.05 (0.66–1.67)	0.84	–	
Type of laser (ref. low power holmium)				
High-power holmium	1.45 (1.09–1.92)	**0.01**	1.63 (1.14–2.34)	**<0.01**
Thulium fiber laser	3.70 (2.55–5.38)	**<0.001**	2.50 (1.32–4.74)	**<0.01**
Lithotripsy mode (ref. pop-corning)				
Dusting	1.95 (1.48–2.46)	**<0.001**	1.34 (0.93–1.92)	0.12
Fragmentation	0.29 (0.22–0.39)	**<0.001**	0.37 (0.25–0.56)	**<0.001**
Combination	1.25 (0.94–1.65)	0.13	–	
Disposable ureteroscope	1.06 (0.83–1.37)	0.63	–	
Ureteroscope tip >8 French	0.80 (0.59–1.10)	0.17	–	
Lasing time	0.99 (0.99–1.01)	0.53	–	
Total surgical time ≥100 min (ref. <100 min)	0.38 (0.28–0.52)	**<0.001**	0.38 (0.26–0.58)	**<0.001**

CI = confidence interval; OR = odds ratio; ref = reference.
Bold value stands for significant *p* value.

judicious use of the surgical time is one of the cornerstones of a safe SSB-RIRS, and in the presence of preoperative predictors of prolonged surgical time (eg, bilateral and large stone burden, and anomalous kidneys), staged procedures or a simultaneous RIRS on one side and percutaneous nephrolithotripsy on the other side [15] should be planned to minimize morbidity.

Another potential issue against SSB-RIRS is the incidence of bilateral ureteral lesions. In our series, a ureteral injury occurred in 2.6% of cases. A grade 2 lesion accordingly to Traxer and Thomas [25] was reported in 12 patients with only one case of bilateral grade 1 injury, and all cases had postoperative stenting only. Hence, this should not preclude urologists from performing SSB-RIRS with a UAS.

The goal of every surgical stone treatment is to render the patient stone-free in a single session, which also applies to bilateral stones. Our study demonstrated that SSB-RIRS was associated with a low incidence of patients who had unilateral (17.4%) and bilateral (9.6%) RFs, and with 55.9% of patients planned for no reintervention, it showed an excellent outcome favoring the use of SSB-RIRS as a first line of intervention for these patients.

Our multivariable analysis infers that the key factors for obtaining bilateral stone-free status were bilateral prestenting and the use of high-power HL and TFL. A recent systematic review also showed that the SFR for RF cutoff of <1 and <4 mm favored prestented patients [26]. This could partially be explained by higher success rates of UAS insertion in prestented patients [26] since the use of a UAS in flexible ureteroscopy allows good irrigation and visualization, and operative efficiency [27], which may be contributory to the good SFR that we achieved. In our study, the use of TFL demonstrated a 2.5-fold odds of being bilateral stone-free. This result can be explained in terms of both its versatile power setting and the ability to dust better and faster, as has been proposed in most recent studies [28]. Indeed, we also found that fragmentation and stone extraction alone was less likely associated with bilateral SFR.

Last but not least, we found that larger stones had lower bilateral SFR with higher reintervention in this subgroup. This indicates the need to caution patients beforehand the possibility of reintervention. Indeed, staged RIRS for large-volume stones has been reported as an acceptable management choice [29].

This study is not devoid of limitations starting from its retrospective nature. We were not able to report all minor complications. Long-term data on ureteral strictures are unavailable, and this is another important issue to analyze. There may be a source of bias in the analysis of SFRs since we used different imaging modalities. SFR assessment could have been more robust if a postoperative CT scan was used to verify this outcome in all patients. However, the real-world usage of combinations of imaging modalities reflects a real-life practice. We should also acknowledge that from a patient's perspective of inherent radiation exposure of CT since <8% of patients undergoing CT for urolithiasis were imaged using a low-dose protocol [30]. It is also well known that since urolithiasis can be considered a chronic condition in many patients suffering from frequent recurrence, radiation exposure would greatly be increased if we were to rely solely on CT, and this is of outmost important in patients suffering for bilateral stones [31]. We were unable to establish why surgeons did not attempt the opposite renal intervention when ipsilateral access to the renal pelvis failed and proceeded to plan a bilateral approach at a later date.

Finally, a cost analysis with staged procedures was not performed. However, maximizing hospital and surgeon resources, avoiding duplicate use of accessories, single operating cost, and importantly one anesthesia are definite winners for advocating this procedure. This in combination with a median surgical time of 75 min, median hospital stay of 2 d, and bilateral SFR of 73% provides strong arguments in favor of SSB-RIRS.

5. Conclusions

Our study demonstrates that SSB-RIRS is an effective treatment for patients with bilateral kidney stones with a short postoperative stay and an acceptable rate of complications. Prestenting, the use of high-power HL and TFL, and avoiding a large stone burden are key factors to achieve bilateral SFR. We recommend that using prophylactic antibiotics, having operative time not exceeding 100 min, and using a UAS will help mitigate the risk of sepsis in SSB-RIRS.

Author contributions: Daniele Castellani had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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