

Spinal versus general anesthesia during retrograde intra-renal surgery: A propensity score matching analysis

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Abstract

Background: The indications for retrograde intra-renal surgery (RIRS) have greatly increased, however, there is still no consensus on the use of spinal anesthesia (SA) during this procedure. The aim of this study was to evaluate the comparability of surgical conditions and outcomes with RIRS performed under SA versus general anesthesia (GA) for renal stones.

Materials and methods: This was a prospective, observational study in patients scheduled for RIRS in a single teaching hospital in Italy. Inclusion criteria were age >18 years and the presence of single or multiple renal stones. We recorded information concerning the site of lithiasis, the number of calculi, total stone burden, and the presence of concomitant ureteral stones or hydronephrosis. A propensity score-matched analysis was performed to evaluate the results in terms of surgical outcome, intraoperative and postoperative complications, and analgesia demand balanced for confounding factors. Patients were followed-up until day 90 from discharge.

Results: We included 120 patients, the propensity score-matched cohort included 40 patients in the SA and 40 in the GA groups. The stone-free rate was 67.5% in the GA group and 70.0% in the SA group ($p=0.81$). The use of auxiliary procedures within 90 days did not differ between groups (25.0% vs. 22.5%, $p=0.79$). No cases of conversion from SA to GA were recorded. We did not find any differences in intraoperative bleedings, perforations, and abortions. Complication rates were similar in the 2 groups (10.0% in GA vs. 5.0% in SA, $p=0.64$).

Conclusions: In our cohort, RIRS performed under SA and GA was equivalent in terms of surgical results and complications.

Keywords: Anesthesia; Minimally invasive therapy; Retrograde intra-renal surgery; Ureteroscopy; Urolithiasis

1. Introduction

Endoscopic management of renal stones has substantially increased in the last decade. American and European guidelines suggest retrograde intra-renal surgery (RIRS) as a treatment option for stones up to 20 mm.^[1–3] However, RIRS also showed efficacy and safety for a large stone burden and multiple lithiasis.^[4–6] With the evolution of instruments and techniques, RIRS gained an established role as a minimally invasive procedure with fast recovery, short hospitalization, and low rates of complications.^[7–10] However, high-grade complications still remain possible,^[11,12] and linked to the use of general anesthesia (GA). In this scenario, the use of spinal anesthesia (SA)

could move toward the reduction of invasiveness, costs, and hospitalization.^[13]

Ureteral stone treatment has been described and widely accepted under SA,^[14] however, GA is usually offered during RIRS because it has some advantages: in case of a large stone burden the lithotripsy is easier with reduced renal movement caused by respiration, the comfort for the patient is expected to be better, and there is no risk for the anesthesia duration to be exceeded. SA also has advantages: it avoids some GA related complications, allows an early mobilization, and is cost effective. Few studies compared different anesthesia modality during RIRS for renal stones and the only randomized controlled trial^[15] compared RIRS performed under combined spinal-epidural anesthesia with GA.^[16]

The aim of this study was to compare surgical results, intraoperative and postoperative complications, and analgesia demand of RIRS performed under SA versus GA.

2. Materials and methods

Data were prospectively collected, as approved by the Institutional Review Board. Inclusion criteria were age ≥ 18 years and single or multiple stones above the ureteropelvic junction. Exclusion criteria were positive urine culture, pregnancy, and urinary tract abnormalities. Patients with a preoperative double-J

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ureteral stent were also excluded from this analysis. Informed consent was obtained from all the patients.

We collected demographic characteristics such as age, gender, body mass index, and the American Society of Anesthesiologists class. General physical examination, complete blood count, serum creatinine, complete blood coagulation, urine analysis, and culture were done in all patients. Stone characteristics and the urinary tract were studied with a computed tomography (CT) scan or with a combination of ultrasonography, and kidney ureter and bladder (KUB) X-ray. A CT scan was performed if clinically necessary. Variables analyzed were the side of involvement, the location of the lithiasis, number of calculi, and the total stone burden (defined as the maximum diameter of the stone or the sum of the maximum diameters in multiple lithiasis). The presence of concomitant ureteral stones or hydronephrosis was also evaluated. Intra-operative data, outcomes, and complication were recorded. We divided the patients in 2 groups, according to the anesthesia regimen chosen by the anesthesiologist: SA and GA.

2.1. Surgical technique

All the procedures were performed by the same expert endourologist (P.B.), who has performed more than 2000 endoscopic treatments of urinary stones. Briefly, endoscopy started with rigid cystoscopy. After bladder and ureteral meatus examination, a safety guide wire was inserted in the ureter and a preliminary evaluation of the ureter was done through ureteropyelography. In all the cases a semirigid ureteroscope (27,000L, Karl Storz) was inserted and the ureter is evaluated until the ureteropelvic junction. If a concomitant ureteral stone was found it was treated in this phase. A second guide-wire or a ureteral access sheath was placed and the renal pelvis was reached with a flexible ureteroscope (FLEX-X2, Karl Storz or URF-P6, Olympus). A 200 μ m Holmium:YAG laser was used for lithotripsy with the dusting technique. Basket extraction of major fragments was only performed when needed. A double J ureteral stent and vesical catheter was placed at the end of all procedures.

2.2. Anesthesia

In all patients, a peripheral vein was cannulated and a single dose of antibiotic prophylaxis was administered and normothermia maintained with warm air devices. Perioperative heart rate, peripheral oxygen saturation, and blood pressure values were monitored until transfer to the urological ward, when the Aldrete score was ≥ 8 .

In the SA group, anesthesia was administered using a 25 gauge atraumatic Sprotte type needle with 10–20 mg hyperbaric 1% or 0.05% bupivacaine at L2–3 level to provide a sensitive block up to T8–10. We administered an intranasal oxygen supply only if SpO₂ was below 92%. Additional sedation was based on midazolam boluses 2 mg or low-dose propofol infusion according to the Schneider model effect-site target-controlled infusion 1 μ g/mL, plus additional low-dose remifentanyl (Minto model effect-site target-controlled infusion 0.5–2 ng/mL) if analgesia was inadequate. Target controlled infusion was titrated based on the clinical response in the SA group.

In the GA group, anesthesia was induced with propofol 2 mg/kg and fentanyl 1 μ g/kg and maintained with either propofol Schneider model effect-site target-controlled infusion, sevoflurane or desflurane plus remifentanyl with the Minto model effect-site target-controlled infusion according to the anesthesiologist's choice. In all cases in the GA group, anesthesia depth was monitored with the entropy index, targeting values

between 40 and 60. After induction, a laryngeal mask was placed avoiding the use of neuromuscular blockade when clinically feasible. We administered ranitidine plus ondansetron intraoperatively as prevention of postoperative nausea and vomiting. An opioid-free postoperative analgesia regimen was preferred, based on acetaminophen 1000 mg plus ketorolac 30 mg. Rescue doses were administered if the pain numeric rating scale was above 4.

2.3. Outcome measures

The primary end-point was the stone-free rate (SFR) at 30 days from surgery. From administrative data, we expected a 1:1 ratio between GA and SA, with an average SFR of 70%. If there was no true difference between GA and SA, we needed to enroll 120 patients in an unmatched cohort to achieve 80% power (1- β) to exclude an unquestionable difference between the 2 techniques. Intra-operative data, outcomes, and complications were recorded. Operative time was measured from the start of the endoscopic procedure until the ureteral stent placement. Postoperative complications were reported using the Clavien-Dindo classification.^[11] Postoperative pain was evaluated by recording the painkillers demand during the hospital stay. The use and numbers of demands for acetaminophen, nonsteroidal antiinflammatory drugs, and opioid use were registered in electronic patient's records. SFR was defined as residual fragments up to a maximum of 4 mm in diameter detected on ultrasound and/or KUB X-ray at 30 days follow-up. SFR was subclassified as recently proposed by Somani et al.^[17] The auxiliary procedures within 3 months from the surgery and the need for re-hospitalization were also recorded.

Patients were divided according to the anesthesia received in 2 groups: the SA group and the GA group.

2.4. Statistical analysis

Due to the nonrandomized nature of the study, a propensity score matching analysis was used to adjust the difference in baseline preoperative parameters between the 2 groups. All preoperative parameters were used to develop the propensity score. Matching was based on the logit of the propensity score with a caliper of 0.2 standard deviations (SD).^[18] Normality was assessed with visual inspection of Q–Q plots and the Shapiro–Wilk test. Continuous variables are reported as a mean \pm SD and compared with the Student's *t*-test. Categorical variables are presented as the absolute frequency (percentage) and compared with the Chi-square or Fisher's test, as appropriate. All the statistical analyses were performed using SPSS v.23 (IBM Corp., Armonk, NY), and significance considered for two-tailed $p < 0.05$.

3. Results

From December 2016 to March 2018, 120 patients were enrolled in this study. After Propensity Score Matching we obtained two homogeneous groups (SA and GA groups) of 40 patients each.

The preoperative characteristics of both groups, before and after matching are reported in Table 1. No meaningful differences were observed between the groups. In the SA group, 11/40 (27.5%) patients received additional target-controlled infusion of low-dose propofol and/or remifentanyl to compensate for a nonsatisfactory control of pain; however, no cases of conversion from SA to GA were recorded. No patient received GA as a rescue strategy for a failed SA attempt. Complete intraoperative and postoperative parameters are shown in Table 2.

Table 1
Patients characteristics in the unmatched and propensity score-matched cohorts.

	Unmatched cohort			Propensity score-matched cohort		
	GA (n=61)	SA (n=59)	p	GA (n=40)	SA (n=40)	p
Age, years	53.2 ± 15.7	58.0 ± 14.6	0.088	54.9 ± 16.9	55.8 ± 13.9	0.77
Sex, n (%)			0.12			0.63
Male	34 (55.7)	41 (69.5)		28 (70.0)	26 (65.0)	
Female	27 (44.3)	18 (30.5)		12 (30.0)	14 (35.0)	
BMI, kg/m ²	24.7 (2.7)	25.4 (2.7)	0.17	25.0 (2.6)	25.4 (2.9)	0.50
ASA class, n (%)			0.29			0.30
I	14 (23)	21 (35.6)		10 (25)	13 (32.5)	
II	41 (67.2)	32 (54.2)		28 (70)	22 (55)	
III	6 (9.8)	6 (10.2)		2 (5.0)	5 (12.5)	
Side, n (%)			0.47			0.50
Right	27 (44.3)	30 (50.8)		19 (47.5)	22 (55)	
Left	34 (55.7)	29 (49.2)		21 (52.5)	18 (45)	
Multiple stones, n (%)	26 (42.6)	29 (49.2)	0.47	17 (42.5)	20 (50.0)	0.50
Concomitant ureteral stones, n (%)	14 (23)	22 (37.3)	0.087	11 (27.5)	11 (27.5)	>0.999
Stone burden, mm	13.8 ± 5.5	11.9 ± 5.4	0.063	12.3 ± 4.1	12.3 ± 5.4	>0.999
Previous stones surgeries, n (%)	41 (67.2)	31 (52.5)	0.101	24 (60.0)	24 (60.0)	>0.999
Stone location, n (%)			0.28			0.65
Superior calyces	5 (8.2)	10 (16.9)		5 (12.5)	4 (10)	
Middle calyces	15 (24.6)	13 (22)		9 (22.5)	7 (17.5)	
Inferior calyces	25 (41)	26 (44.1)		16 (40)	18 (45)	
Renal pelvis	39 (63.9)	32 (54.2)		24 (60)	24 (60)	
Hydronephrosis, n (%)	19 (31.1)	30 (50.8)	0.028	15 (37.5)	17 (47.5)	>0.999

ASA = American Society of Anesthesiologists; BMI = body mass index.

Table 2
Intraoperative and postoperative results.

	GA (n=40)	SA (n=40)	p
Time, minutes	54 ± 33	45 ± 19	0.17
Intraoperative bleeding, n (%)	2 (5.0)	1 (2.5)	0.70
Ureteral perforation, n	0	0	
Abortion, n (%)	1 (2.5)	4 (10)	0.16
Overall complications, n (%)	4 (10)	2 (5)	0.64
Clavien grade			0.36
I	0	1 (2.5)	
II	4 (10)	1 (2.5)	
III	0	0	
Period of hospitalization, days	1.5 ± 1.3	1.5 ± 2.2	>0.99
Pain killers demand, n (%)	11 (27.5)	10 (25.0)	0.79
Pain killers, n (%)			0.70
Acetaminophen	8 (20.0)	9 (22.5)	
NSAIDs	2 (5.0)	1 (2.5)	
Opioids	1 (2.5)	0	
Number of drugs administration	1.4 ± 1	1.4 ± 1.2	>0.99
Stone free, n (%)	27 (67.5)	28 (70)	0.80
Residual fragments, n (%)	21 (52.5)	20 (50)	0.82
Mean residual stone burden, mm	7.6 ± 5.7	4.9 ± 3	0.066
SFR level, n (%)			0.8
0	19 (47.5)	18 (45.0)	
1	1 (2.5)	0	
2	3 (7.5)	4 (10.0)	
3	1 (2.5)	2 (5.0)	
4	3 (7.5)	4 (10.0)	
Auxiliary procedures, n (%)	10 (25)	9 (22.5)	0.79
Auxiliary outcomes, n (%)			0.69
Ureteroscopy	4 (10)	3 (7.5)	
Percutaneous nephrolithotomy	0	0	
ESWL	6 (15)	6 (15)	

ESWL = extracorporeal shock wave lithotripsy; GA = general anesthesia; NSAID = nonsteroidal anti-inflammatory drug; SA = spinal anesthesia.

3.1. Intraoperative parameters

The average operative time was similar between the 2 groups. We did not notice any difference in terms of intraoperative bleedings or perforations.

3.2. Postoperative complications and analgesia demand

In the GA group we registered 4 cases of fever (Clavien-Dindo grade II), which were treated with intravenous antibiotics. In the SA group, we found one febrile patient and one patient with postoperative hematuria (Clavien-Dindo grade I) that did not require any further treatment. No septic patients were present in the 2 groups. This difference did not show any statistical significance. The hospital stay was equal in both groups.

The demand for analgesia and the type of painkiller used did not differ in the 2 groups.

3.3. SFR and auxiliary outcomes

SFR was 67.5% in the GA group and 70.0% in the SA group (p = 0.809), with 21 and 20 measurable residual fragments, respectively (p = 0.823), also the analysis of SFR level subgroup did not show any statistically significant difference.

Ten patients from the GA group had a second procedure within 3 months (4 second look RIRS and 6 ESWL treatments). In the SA group, 3 patients received a second look RIRS and 6 patients underwent ESWL. No patients required additional hospitalization or showed hydronephrosis at the 30-day follow-up ultrasonography.

4. Discussion/conclusion

In this study, we report similar SFR, intraoperative and postoperative outcomes in patients treated with RIRS under GA versus SA.

Our results concord with the previous published studies and added value to the use of SA for RIRS, particularly when a fast recovery and a short hospitalization are intended to be achieved.

In the last years, due to the improvement and development of flexible ureteroscopes and new essential devices for safe, fast, and effective minimally invasive procedures, RIRS has become more popular.

The 2018 EAU Urolithiasis Guidelines states that for retrograde stone removal both local and SA is feasible, however, the majority of patient still undergo GA.^[13] It was demonstrated that SA reduces anesthesiologic costs when compared with GA.^[19] SA is widely accepted for transurethral procedures on the bladder and prostate.^[20] Generally, the anesthesiologist during rapid endoscopic procedures proposes SA because it has lower risks of anaphylaxis, vascular, pulmonary, and neurological complication and compared with GA it does not present the risk of intubation-related problems.^[21]

Historically SA with or without sedation was proposed for patients with ureteral calculi, more frequently distal than proximal and in pregnant women.^[14] Park et al^[22] reported a 93% success rate in ureteroscopic lithotripsy for stones located in the middle-low ureter performed under local anesthesia with intramuscular analgesic injection and lidocaine local gel application.

Emiliani et al.^[23] purposed the use of apnea and GA during RIRS, in order to avoid renal movement and facilitate the procedure for complex cases.

There were few clinical studies comparing RIRS under SA versus GA. In a randomized controlled trial, Zeng et al^[15] compared 2 groups of patients treated with RIRS in combined spinal-epidural anesthesia ($n=31$) or in GA ($n=34$). They concluded that RIRS with spinal-epidural anesthesia has the same efficacy and safety compared with GA. However, despite that the study was randomized, the stone characteristics were not homogeneous between the 2 groups. Furthermore, the positioning of an epidural catheter unnecessarily prolongs the time of hospitalization without significantly reducing the postsurgical pain, so it is not applicable in a high turn-over department. The paper from Bosio et al.^[16] compared SA alone as an alternative to GA and focused on a day-surgery setting, and the authors did not find any difference in outcomes measured as SFR, residual fragments, operative times, and complications.

According to the literature, and in our study we did not find any statistically significant differences in terms of intraoperative and postoperative complication, analgesia demand, and SFR in patients with single or multiple renal stones with a stone burden up to 30 mm treated with flexible ureteroscopy in GA versus SA. We noticed a higher number of interrupted procedures, due to the difficulties of reaching the renal pelvis with the instruments, in the SA group (10% vs. 2.5%, $p=0.166$) albeit not statistically significant.

Several issues regarding the study design deserve further comment. First, the design of the study was not randomized, however, the Propensity Score Matching method allows obtaining a perfect overlay of the preoperative parameter without confounding factors^[24] avoiding the difficulties of surgical randomized clinical trials. Second, the sample of the study was relatively small. Third the preoperative stone burden, as demonstrated by Ito et al.^[25] was the most significant parameters prolonging operative time and that consequently could affect SFR, and the complication rate, was not measured with a CT scan in all the patients. However a KUB combined with abdominal ultrasonography focused on the detection of residual fragments

was enough to correctly evaluate the patient, limiting costs, and X-ray exposure.^[26] Last, to evaluate postoperative pain we used the demand for analgesic drugs, the medication used, and the number of assumptions during the stay instead of the visual analogue scale or numeric scale, as this method is more objective in explaining the real need of analgesia. Moreover, we did not record the incidence of postdural puncture headache incidence in the SA group and the rate of difficult airway management in the GA group.

In conclusion, we can affirm that RIRS performed under GA and SA are equivalent in terms of results and complications.

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Statement of ethics

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest statement

No conflict of interest has been declared by the author.

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Author contributions

Protocol/Project development: Alberto Olivero, Lorenzo Ball, Carlotta Fontaneto, Guglielmo Mantica, Paolo Bottino, Paolo Pelosi, Carlo Terrone.

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