Comparison of the effects of general, spinal and epidural anesthesia on ureter access and surgical outcomes during flexible ureterorenoscopy for transurethral single stone removal surgeries: a monocentric retrospective study

Haoliang Cai, Xiaohui Wu, Xi Chen and Wenting Chen

Department of Anesthesiology, Shuguang Hospital Affiliated to Shanghai University of Traditional Chinese Medicine, Shanghai, China

ABSTRACT

Background: In ureterorenoscopy, anaesthesiologists are preferring regional anaesthesia to avoid postoperative complications, while surgeons are preferring general anaesthesia to avoid ureteral trauma. China has not published its guidelines and not referring to the European Association of Urology guidelines. The objectives of study were to evaluate the effects of general, spinal, and epidural anaesthesia on ureter access and surgical outcomes of ureterorenoscopy.

Methods: Charts of a total of 392 patients with the American Society of Anaesthesiologists grade I or II, and underwent flexible ureterorenoscopy for removal of the proximal, middle, or distal ureteral single stone under general anaesthesia (GA group; n = 145) or spinal anaesthesia (SA group; n = 131) or epidural anaesthesia (EA group; n = 116) were reviewed retrospectively.

Results: The dilatation time for patients of GA group was fewer than those of SA (104.01 ± 12.77 sec/patient vs. 130.55 ± 22.53 sec/patient, p < .0001, q = 17.0350) and EA (104.01 ± 12.77 sec/patient vs. 147.03 ± 18.76 sec/patient, p < .0001, q = 26.7240) groups. The time to reach to stone for patients of GA group was fewer than those of SA (126.68 ± 12.59 sec/patient vs. 137.60 ± 18.76 sec/patient, p < .0001, q = 8.4510) and EA (126.68 ± 12.59 sec/patient vs. 149.44 ± 18.76 sec/patient, p < .0001, q = 17.0350) groups. The lithotripsy time (p = .359), operation time (p = .449), intraoperative complications (p = .058), and length of hospital stays (p = .057) of patients were same among groups. Visual analog scale pain scores of patients of the GA group found higher among groups. General anaesthesia caused nausea and vomiting.

Conclusions: This study suggests general anaesthesia for flexible ureterorenoscopy if there is no contraindication.

KEY MESSAGE

- General anaesthesia facilitates early dilatation of ureters and access to the stone.
- No strong correlation of the anaesthesia method of choice with lithotripsy time, operation time, intraoperative complications, stone-free conditions, and length of hospital stays.
- Epidural and spinal anaesthesia have advantages of fewer postoperative pain and better postoperative outcomes for flexible ureterorenoscopy.

Abbreviations: ASA: The American Society of Anaesthesiologists; α: type-I error; β: type-II error; GA group: patients underwent general anaesthesia; SA group: patients underwent spinal anaesthesia; EA group: patients underwent epidural anaesthesia; VAS: Visual Analog Scale Pain Score; SD: standard deviation; ANCOVA: analysis of covariance; q: critical value for Tukey test.

Introduction

The prevalence of kidney stones in mainland China is increased because of the Western-like lifestyle of the population and the development of imaging devices [1]. Also, the relatively high animal protein intake of the Chinese population has increased the incidence of kidney stones [2]. Ureterorenoscopy is the preferred surgical procedure for the management of ureteral stones not been amenable to medical expulsive therapy since 1980 [3]. It has a higher stone-free rate compared to shockwave lithotripsy and a lower complication rate compared to percutaneous nephrolithotomy [4] because of advanced technology and modern procedural equipment [3].
Patient selection, appropriate use of surgical instruments, and the proper technique increase the reliability and success of ureterorenoscopy. Ureteral access is an important step in ureterorenoscopy. The success of ureteral access and the process of reaching the stone depending on the axial force in the orifice [3]. In primary surgery, ureteral access is not always possible and excessive force can cause ureteral injuries [5]. Studies reported that ureterorenoscopy outcome results are succeeded by achieving ureteral access [3]. Ureteral balloon dilatation, preoperative stent implantation with passive dilatation, and preoperative \( \alpha \)-blocker improve ureteral access but all these methods have advantages and disadvantages [6].

The European Association of Urology guideline [7] recommends ureterorenoscopy to be performed under general anaesthesia. Spinal and local anaesthesia are also available options. Intravenous sedation also recommends in distal ureteral stones, especially in female patients. China has not published its guidelines and not referring to the European Association of Urology guidelines regarding treatment for urolithiasis [8]. In ureterorenoscopy, anaesthesiologists prefer regional anaesthesia to avoid complications due to general anaesthesia [3], while surgeons prefer general anaesthesia to avoid ureteral trauma [9]. Prospective randomized studies [3,10,11] show that the anaesthesia method has effects on ureteral access and influences ureteral entrance through surgical success but they have a small sample size. In literature, ureterorenoscopy is described under general anaesthesia, local anaesthesia, sacral block, and spinal anaesthesia [12,13]. However, the debate is continued on loco-regional anaesthesia for ureterorenoscopy [14].

The objectives of a monocentric retrospective analysis were to compare outcomes of flexible ureteroscopy and lithotripsy in patients who underwent surgical outcomes for transurethral ureterorenoscopy stone removal surgeries by regional, epidural, or regional anaesthesia.

Materials and methods

**Ethical approval and consent to participate**

The designed protocol (SUTCM02201 dated 31 January 2021) was approved by the Shanghai University of Traditional Chinese Medicine review board and the Chinese Urological Association. The study reporting adheres to the law of China and the V2008 Declarations of Helsinki. An informed consent form was signed by patients and/or caregivers of patients regarding diagnosis, surgeries, and publication of the anonymized information of patients in the form of an article(s).

**Study population**

From 15 November 2019 to 1 December 2020, a total of 461 patients age 18 years or more, and underwent ureterorenoscopy for removal of the proximal, middle, or distal ureteral stones at the department of urology of the Shuguang Hospital Affiliated to Shanghai University of Traditional Chinese Medicine, Shanghai, and the referring hospitals. Among these patients, 15 patients have received chronic pain management, 11 patients had already double “J” stent, 13 patients had previous surgeries, two patients had the neurogenic disease(s), three patients had urethral stenosis, two patients had ureteric stenosis, one patient had any kidney abnormality, eight patients had multiple stones (ureterorenoscopy stone removal surgeries is hampered for their performance and side effects for more than one stone [15]), ureteral access was unsuccessful in 12 patients, and two patients were with the American Society of Anaesthesiologists (ASA) status ≥ grade III [16]. Therefore, data of these patients (n = 69) were excluded from the analysis. Data on preoperative, intraoperative, and postoperative characters of a total of 392 patients who underwent transurethral ureterorenoscopy stone removal surgeries (flexible ureterorenoscopy) for proximal, middle, or distal ureteral stones were retrospectively collected from medical records of patients after getting written approval from authorities. The flow diagram for the management of ureteral stones is presented in Figure 1.

**Sample size calculation**

The study assumed that 80 ± 5% of patients would be reached stone-free condition after 4 weeks of ureterorenoscopy. The sample size was calculated on the assumption of stone-free rate, 5% two-sided type-I error (\( \alpha = 0.05 \)), and 80% power (\( \beta = 0.2 \); type-II errors) at 95% of confidence level using OpenEpi (Open-Source Epidemiologic Statistics for Public Health, USA) software [5]. The sample size (minimum patients required in each group) was reported as 100.

**Types of anaesthesia**

All patients have received 1g ceftriaxone (ADD-Vantage®, Sandoz GmbH, Berlin, Germany) 30 min before the operation as prophylactics. A total of 145
patients underwent ureterorenoscopy under general anaesthesia (GA group). A total of 131 patients underwent ureterorenoscopy under spinal anaesthesia (SA group). A total of 116 patients underwent ureterorenoscopy under epidural anaesthesia (EA group). Patients who were on the treatment of β-or α-blockers or calcium channel blockers underwent ureterorenoscopy under spinal or epidural anaesthesia.

**Anaesthesia method**

Using an intravenous cannula (Venflon™, Becton Dickinson and Company, Franklin Lakes, NJ, USA), vascular access was established in the preparation room. Hemodynamic parameters (systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate, and oxygen saturation) were monitored by a patient care monitor (Intellivue MX450, Koninklijke Philips N.V., Amsterdam, Netherlands). The anaesthesia method was performed by anaesthesiologists (with a minimum of 3-years of experience) of institutes. If anaesthesia was performed by resident anaesthesiologists, there was a specialist always monitoring them.

**General anaesthesia**

Patients were preoperatively oxygenated with 100% oxygen for 4–5 min in the operation room. A total of 2 μG/kg fentanyl (Durogesic, Johnson & Johnson Pvt. Ltd., IL, USA), 2–3 mg/kg propofol (Fresofol, Fresenius Kabi AG, Bad Homburg, Germany), and 0.5 mg/kg rocuronium (Zemuron, Mylan NV, Hertfordshire AL, UK) were administered. Endotracheal intubation using an endotracheal tube (Rosch Medical Systems Private Limited, Tucson, Arizona, USA) was performed after administration of muscle relaxation. In the requirements of artificial respirations, controlled ventilation was provided at 8–10 mL/kg tidal volume and 10–12 min respiratory frequency. The anaesthesia was maintained with 50% oxygen and 50% nitrous oxide.

Figure 1. The flow diagram for management of ureteral stones.
in 1% of the minimum alveolar concentration of sevoflurane (Sevorane, Abbott Healthcare Pvt. Ltd., Cades, SC, USA).

**Spinal anaesthesia**

Patients were hydrated with 500 mL of balanced electrolyte solution (Baxter Pharmaceuticals Pvt. Ltd.) 30 min before operation. After skin cleaning with alcohol, using a spinal needle (Becton Dickinson and Company, Franklin Lakes, NJ, USA; 25 G or 26 G as per requirements) at L3–4 or L4–5 and the midline approach technique, the spinal needle was entered. When the clear cerebrospinal fluid was observed, 2 mL bupivacaine (Marcaine™ Spinal, Uni-Amp™, Hospira, Inc., Lake Forest, IL, USA) was administered slowly. The pin-prick test was used to evaluate the sensory block levels of the patients. The surgical procedure was initiated when the area of the anaesthetized dermatome reached the level of T₈–T₆.

**Epidural anaesthesia**

After routine monitoring in the preparation room, the skin was cleaned in the sitting position with rubbing alcohol. Using an 18 G needle (Becton Dickinson and Company, Franklin Lakes, NJ, USA), puncture was made at T₁₁ to T₁₂ range. The epidural range was obtained by the negative pressure method and an epidural catheter (Rosch Medical Systems Private Limited, Tucson, Arizona, USA) was placed. After applying 3 mL of prilocaine (Citanest® 2% 20 mg, Densply Pharmaceuticals, USA) as a test dose, 1.5 mL of prilocaine was added to each segment. The surgery was started when the sensory block reached the T₆ level.

**Flexible ureterorenoscopy**

After anaesthesia, 0.038-inch hydrophilic guidewire (Boston Scientific Corporation, Natick, MA, USA) was inserted in the position of modified dorsal condition. The dilatation was obtained by inserting the ureter with a 9.5 F scope (Karl Storz®, Tuttlingen, Germany). When the stone was visualized, a probe compatible with 200 μm of holmium laser (Quanta System®, Litho 30 W, Milan-Italy) was used for surgeries. At 8–15 Hz frequencies and 1.2–3.0 Joule power, the lithotripsy was performed. When the stone was completely fragmented, the procedure was terminated. Doble “J” stent (6 or 4.7 Fr diameter and 24 or 26 cm diameter, Becton Dickinson and Company, Franklin Lakes, NJ, USA) was placed in all patients. The visual Analog Scale (VAS) score for pain assessment was evaluated after the surgical procedure at the 8th and 24th hours. When patients became conscious, patients were prescribed tramadol 50 mg and paracetamol 350 mg (Ultracet, Johnson & Johnson, New Brunswick, NJ, USA) twice a day with 500 mg twice a day levofloxacin (Glevo, Glenmark Pharmaceuticals Ltd., Mumbai, India) for 5 days. After one day of the procedure, the location and status of the stent were accessed by direct urinary tract X-ray and non-opaque stones were evaluated by urinary system ultrasonography (Koninklijke Philips N.V., Amsterdam, Netherlands). After 4 weeks, patients were called for the withdrawal of stent. At this stage, the computed tomography images were also obtained for the evaluation of the stone-free condition. Ureterorenoscopy procedures were performed by urologists (with a minimum of 3-years of institutional experience of urological surgeries). If ureterorenoscopy was performed by resident urologists, there was a specialist always monitoring them.

**Preoperative demographic and clinical characters**

Demographical parameters (age, sex, and body mass index), conditions of stone according to the computed tomography images (size (longest diameter), volume, status, side, and localization), and ASA status were evaluated before ureterorenoscopy. Preoperative demographic characters were evaluated by nursing staff with a minimum of 3-years of experience in institutes.

**Intraoperative characters**

Dilatation time, time to reach to stone, and the lithotripsy time were recorded. Intraoperative complications and operation time were also recorded. Intraoperative characters, intraoperative complications, and operation time were recorded by operating urologists.

**Dilatation time**

The period of onset from the urethral meatus access with the ureteroscope, under the guidance of the institutional guidelines, until the entry of the orifice.

**Time then reached to stone**

The period from the beginning of orifice entry until the stone appears.
Lithotripsy time
The period of stone crushing.

Intraoperative complications
Intraoperative complications were classified according to the modified SATAVA classification system. Grade 1: events treated without consequences for the patient, Grade 2a: events treated intraoperatively with endoscopic surgeries, Grade 2b: events required endoscopic re-treatment, Grade 3: events requiring open or laparoscopic surgeries for treatments [17].

Operation time
The period of onset from the urethral meatus access with ureteroscope to the placement of double "J" stent placement time.

VAS pain score
VAS score was administered by the nursing staff (unaware of anaesthesia methods) of the institutes. 0: absent pain and 10: maximum possible pain [18].

Length of hospital stays
From the admission to discharge of hospital was considered as the length of the hospital stays.

Stone free condition
A total of 4 weeks after ureterorenoscopy, when patients were called for the withdrawal of stent if the computed tomography images did not show stone or possessed stone with \( \leq 3 \) mm in size (urinary culture) was considered as stone-free condition [3]. Stone-free conditions were evaluated by urologists (with a minimum of 3 years of institutional experiences of urological surgeries).

Postoperative complications
Patients were available in follow-up at 1, 4, and 8 weeks after surgical procedures. The modified CLAVIEN classification system was used for grading postoperative complications within 8 weeks after surgeries. Postoperative complications were recorded by operating urologists. Grade I: events treated without any pharmacological, surgical, radiological, and/or endoscopic interventions. Grade II: events treated using pharmacological, blood, blood products, and/or parenteral interventions. Grade IIIa: events treated using surgical, radiological, and/or endoscopic interventions without using general anaesthesia. Grade IIIb: events treated using surgical, radiological, and/or endoscopic interventions using general anaesthesia. Grade IVa: single organ dysfunction(s) including dialysis, Grade IVb: multiple organ dysfunctions. Grade V: death of the patient. Suffix "d" indicates disability at the time of discharge [19].

Statistical analysis
IBM SPSS Statistics for Windows, Version 26.0 (Armonk, NY, USA: IBM Corp) was used for statistical analysis purposes. Categorical variables are presented as frequency (percentages). Numerical variables are presented as mean ± standard deviation (SD). For categorical variables, the Chi-square test for Independence and continuous variables, analysis of covariance (ANCOVA) was used for statistical analysis. The Tukey test (considering critical value \( q > 3.326 \) as significant) was used for post hoc analysis. A multivariable analysis method was used for evaluation of the effect of anaesthesia time by age, ASA category, and stone volume with all dependent variables including dilation time, the time to reach to stone, lithotripsy time, operation time, and complications. All results were considered significant if \( p < .05 \).

Results
Demographic and clinical characters
Patients with urinary tract infections in pathology had received 500 mg twice day levofloxacin (Glevo, Glenmark Pharmaceuticals Ltd., Mumbai, India) for 5 days treatment before surgeries. Only patients with 55 years and below age received general anaesthesia. There were no significant differences between sex, ethnicity, body mass index, preoperative demographic, and clinical characters, characters of stones evaluated by the computed tomography, co-morbidity of patients, and hydronephrosis before ureterorenoscopy (\( p > .05 \) for all characters). Patients enrolled in the GA group were younger than those of the SA and EA groups. EA group had a higher percentage of patients with ASA status II than those of GA and SA groups and the SA group also had a higher percentage of patients with ASA status II than those of the GA group. The details of preoperative demographic conditions and characters of stones evaluated by the computed tomography are presented in Table 1.
Intraoperative characters

The dilatation time of patients of GA group was fewer than those of SA (104.01 ± 12.77 sec/patient vs. 130.55 ± 22.53 sec/patient, p < .0001, q = 17.035) and EA (104.01 ± 12.77 sec/patient vs. 147.03 ± 18.76 sec/patient, p < .0001, q = 26.72) groups. Also, the dilatation time was fewer for patients of SA group than those of EA group (p < .0001, q = 2.924). The details of the time to reach to stone are represented in Figure 3.

None of the patients had reported abnormality regarding hemodynamic parameters (systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate, and oxygen saturation) during surgical procedures. The lithotripsy time (p = .359), operation time (p = .449), intraoperative complications (p = .058), and length of hospital stays (p = .057) were the same for patients among groups. Only the modified SATAVA classification grade 1 type intraoperative complications were reported during ureterorenoscopy for patients. The details of the intraoperative characters of the patients are reported in Table 2.

### Table 1. Preoperative demographic, clinical, and pathological characters of the enrolled patients.

| Parameters                                | General GA | Spinal SA | Epidural EA | Comparisons                      |
|-------------------------------------------|------------|-----------|-------------|----------------------------------|
| Numbers of patients who underwent ureterorenoscopy | 145        | 131       | 116         | GA vs. SA        |
| Sex                                       |            |           |             | GA vs. EA        |
| Male                                      | 114 (79)   | 92 (70)   | 82 (71)     | 0.208, N/A, N/A, N/A       |
| Female                                    | 31 (21)    | 39 (30)   | 34 (29)     |                                 |
| Age (years)                               | 20         | 20        | 20          | <.0001, 5.832, 8.636, 2.924   |
| Minimum                                   | 55         | 65        | 66          |                                 |
| Mean ± SD                                 | 39.79 ± 8.42 | 40.01 ± 11.76 | 47.78 ± 11.32 | |
| Ethnicity                                 |            |           |             |                                 |
| Han Chinese                               | 133 (91)   | 119 (90)  | 106 (91)    | .998, N/A, N/A, N/A       |
| Mongolian                                 | 10 (7)     | 10 (8)    | 8 (7)       |                                 |
| Tibetan                                   | 11 (1)     | 11 (1)    | 1 (1)       |                                 |
| Uighur Muslims                           | 1 (1)      | 1 (1)     | 1 (1)       |                                 |
| Body mass index (kg/ m²)                  | 25.22 ± 1.97 | 25.52 ± 2.01 | 25.89 ± 3.11 | <.0001, 4.304, 7.659, 3.414   |
| Hemoglobin (g/ dL)                        | 11.19 ± 2.11 | 11.25 ± 1.99 | 11.35 ± 2.44 | .079, N/A, N/A, N/A       |
| Serum creatinine                          | 0.68 ± 0.11 | 0.69 ± 0.15 | 0.65 ± 0.14 | .053, N/A, N/A, N/A       |
| The American Society of Anaesthesiologists status |          |           |             |                                 |
| I                                         | 91 (63)    | 59 (52)   | 35 (30)     | <.0001, 4.304, 7.659, 3.414   |
| II                                        | 54 (37)    | 72 (44)   | 81 (70)     |                                 |
| Stone size (longest diameter; mm)         | 11.45 ± 3.49 | 11.11 ± 2.89 | 10.89 ± 1.87 | .286, N/A, N/A, N/A       |
| Stone volume (mm³)                        | 553.45 ± 25.45 | 552.12 ± 24.48 | 560.41 ± 35.11 | .051, N/A, N/A, N/A       |
| Stone side                                |            |           |             |                                 |
| Right                                     | 71 (49)    | 69 (53)   | 61 (53)     | .782, N/A, N/A, N/A       |
| Left                                      | 74 (51)    | 62 (47)   | 55 (47)     |                                 |
| Stone status                              |            |           |             |                                 |
| Opaque                                    | 130 (90)   | 118 (90)  | 106 (91)    | .737, N/A, N/A, N/A       |
| Semipaque                                 | 5 (3)      | 4 (3)     | 1 (1)       |                                 |
| Non-opaque                                | 10 (7)     | 9 (7)     | 9 (8)       |                                 |
| Stone localization                        |            |           |             |                                 |
| Upper                                     | 46 (32)    | 42 (32)   | 41 (35)     | .419, N/A, N/A, N/A       |
| Middle                                    | 51 (35)    | 51 (39)   | 32 (28)     |                                 |
| Lower                                     | 48 (33)    | 38 (29)   | 43 (37)     |                                 |
| Co-morbidity                              |            |           |             |                                 |
| Absent                                    | 130 (90)   | 120 (92)  | 101 (87)    | .508, N/A, N/A, N/A       |
| Present                                   | 15 (10)    | 11 (8)    | 15 (13)     |                                 |
| Hydronephrosis                            |            |           |             |                                 |
| Absent                                    | 96 (66)    | 77 (59)   | 68 (59)     | .639, N/A, N/A, N/A       |
| Grade I                                   | 15 (10)    | 19 (14)   | 11 (9)      |                                 |
| Grade II                                  | 16 (11)    | 18 (14)   | 18 (16)     |                                 |
| Grade III                                 | 18 (13)    | 17 (13)   | 19 (16)     |                                 |

Categorical parameters are presented as frequency (percentages). Numerical and ordinal parameters are presented as mean ± standard deviation (SD). The Chi-square test for Independence (for categorical parameters) or ANCOVA (for numerical and ordinal parameters) was used for statistical analysis. The Tukey test was used for post hoc analysis. All results were considered significant if p < .05 and q > 3.326. N/A: not applicable.
VAS pain score

At 8th hour after surgical procedure, VAS pain score of patients of the GA group was higher than that of SA (4.99 ± 1.56 vs. 4.05 ± 0.81, \( p < .0001, q = 12.049 \)) and EA (4.99 ± 1.56 vs. 3.57 ± 0.65, \( p < .0001, q = 17.752 \)) groups. At the 8th hour after surgical procedure, the VAS pain score of patients of the SA group was higher than that of the EA group (\( p < .0001, q = 5.777 \)). At 24th hour after surgical procedure, VAS pain score of patients of the GA group was higher than that of SA (2.82 ± 0.91 vs. 1.98 ± 0.79, \( p < .0001, q = 12.398 \)) and EA (2.82 ± 0.91 vs. 1.59 ± 0.61, \( p < .0001, q = 17.716 \)) groups. At the 24th hour after surgical procedure, the VAS pain score of patients of the SA group was higher than that of the EA group (\( p < .0001, q = 5.588 \)). The details of the VAS pain score of patients are presented in Figure 4.

Stone free condition

A total of 127 (88%) patients from the GA group, 111 (85%) patients from the SA group, and 99 (85%) patients from the EA groups have reported stone-free conditions. There were no significant differences in the numbers of patients with stone-free conditions among groups (\( p = .773 \)).

Postoperative complications

During 8 weeks after ureterorenoscopy, only the modified CLAVIEN classification system grades I, II, IIIa, and IIIb type postoperative complications were reported. None of the patients was discharged with a disability. There were no significant differences for postoperative complications of patients among groups (\( p > .05 \) for all) except nausea and vomiting. General anaesthesia caused nausea and vomiting. The details of postoperative complications with the modified CLAVIEN classification system grades are shown in Table 3.

The effect of anaesthesia time by characteristics

Stone volume higher than 500 mm\(^3\) was responsible for higher lithotripsy time, higher operation time, and complications. The details of the effect of anaesthesia time by characteristics are presented in Table 4.

Table 2. Intraoperative characters, operation time, and intraoperative complications of the enrolled patients.

| Parameters                          | Groups          | General | Spinal | Epidural | Comparisons |
|-------------------------------------|-----------------|---------|--------|----------|-------------|
| Numbers of patients who underwent ureterorenoscopy | GA 145 | SA 131 | EA 116 |          |             |
| Lithotripsy time (min)              |                 | 11.90 ± 1.47 | 12.08 ± 1.35 | 12.13 ± 1.41 | .359        |
| Operation time (min)                |                 | 40.02 ± 3.65 | 40.42 ± 4.15 | 39.81 ± 3.81 | .449        |
| Intraoperative complications        | Modified SATAVA classification grade 1 | 19(13) | 28(21) | 28(24) | .058        |
| Length of hospital stays            |                 | 2.08 ± 0.25 | 2.05 ± 0.17 | 2.02 ± 0.16 | .057        |

Categorical parameters are presented as frequency (percentages). Numerical parameters are presented as mean ± standard deviation (SD). ANCOVA was used for statistical analysis. The Tukey test was used for post hoc analysis. All results were considered significant if \( p < .05 \).
Discussion

According to the study results, general anaesthesia for ureterorenoscopy can save the dilatation time and the time to reach the stone of patients in comparison to spinal anaesthesia and epidural anaesthesia. The results of the intraoperative characters of the present study agreed with those of a prospective randomized study [3]. Regional and spinal anaesthesia is not enough to provide relaxation of distal ureters to access stone [5,10,12]. The use of medications including α-blockers, calcium channel blockers, etc. which could have an effect on ureter relaxation/dilation in each group. However, such studies are not reported yet. Further study is required for the same. General anaesthesia facilitates early dilatation of ureters and access to the stone.

The study reported insignificant differences for lithotripsy time, operation time, intraoperative complications, length of hospital stays, stone-free condition, and postoperative complications among groups. The results of the intraoperative and postoperative characters of the present study are consistent with those of prospective randomized studies [3,10,11,20,21] but are not consistent with a Quasi-experimental study [22]. A small sample size (type I error) of a Quasi-experimental study [22] is responsible for contradictory results. Intraoperative and postoperative characters are almost the same for all anaesthesia techniques because they have no strong correlation to the anaesthesia method.

![Figure 4. Visual analog scale pain score. 0: absent pain and 10: maximum possible pain. *Higher than those of the EA group. †Higher than those of the SA group.](image)

Table 3. Postoperative complications with a grade of the enrolled patients during 8-weeks after ureterorenoscopy.

| Complications Groups | General | Spinal | Epidural | p-Value | q-Value |
|----------------------|---------|--------|----------|---------|---------|
| Numbers of patients who underwent ureterorenoscopy | 145 | 131 | 116 | | |
| The modified CLAVEN classification system grade | Complications | GA | SA | EA | GA vs. SA | GA vs. EA | SA vs. EA |
| I | Mucosal injury | 15 (10) | 11 (8) | 11 (9) | .859 | N/A | N/A | N/A |
| II | Hematuria | 11 (8) | 11 (8) | 10 (9) | .949 | N/A | N/A | N/A |
| II | Fever | 4 (3) | 3 (2) | 4 (3) | .859 | N/A | N/A | N/A |
| II | Obstructive diuresis | 4 (3) | 4 (3) | 3 (3) | .975 | N/A | N/A | N/A |
| II | Elevation in renal functions | 4 (3) | 3 (2) | 2 (2) | .859 | N/A | N/A | N/A |
| II | Retention of urine | 7 (5) | 7 (5) | 6 (5) | .981 | N/A | N/A | N/A |
| II | Urinary tract infections | 13 (9) | 12 (9) | 11 (9) | .989 | N/A | N/A | N/A |
| II | Proximal stone migration | 8 (6) | 7 (5) | 6 (5) | .993 | N/A | N/A | N/A |
| II | Stent migration | 5 (3) | 4 (3) | 3 (3) | .923 | N/A | N/A | N/A |
| II | Urosepsis | 3 (2) | 2 (2) | 2 (2) | .943 | N/A | N/A | N/A |
| II | Hydronephrosis | 2 (1) | 1 (1) | 1 (1) | .862 | N/A | N/A | N/A |
| II | Nausea and vomiting | 5 (3) | 0 (0) | 0 (0) | .013 | 3.632 | 3.514 | N/A |

Parameters are presented as frequency (percentages).
ANCOVA was used for statistical analysis.
The Tukey test was used for post hoc analysis.
All results were considered significant if \( p < .05 \) and \( q > 3.326 \).
N/A: not applicable.

Table 4. A multivariable analysis for evaluation of the effect of anaesthesia time by characteristics.

| Characteristics | Dilation time | The time then reached to stone | Lithotripsy time | Operation time | Complications |
|-----------------|---------------|-------------------------------|-----------------|---------------|---------------|
| Age (<55 years vs. ≥55 years) | 0.081 | 0.065 | 0.072 | 0.079 | 0.061 |
| The American Society of Anaesthesiologists status (II vs. I) | 0.053 | 0.064 | 0.069 | 0.071 | 0.077 |
| Stone volume (<500 mm³ vs. >500 mm³) | 0.055 | 0.063 | 0.045* | 0.046* | 0.048* |

\( p \)-Value less than .05 was considered significant.
*Significant value.
of choice but rather, more related to individual recovery and surgery itself.

Patients receiving general anaesthesia had lower postoperative outcomes including more postoperative VAS pain scores and postoperative nausea and vomiting. The results of the postoperative outcomes of the present study agreed with those of prospective randomized studies [3,10,11] and a Quasi-experimental study [22]. Epidural and spinal anaesthesia have advantages of fewer postoperative pain and better postoperative outcomes for ureterorenoscopy. However, as expected, age was related to the method of anaesthesia (general anaesthesia was only applied in patients below 55 years of age) and it could alter the VAS perception. Also, larger-diameter ureteral stents induce significantly worse urinary symptoms compared to smaller-diameter ureteral stents [23]. Further analysis is required for the same.

The study found that stone volume had effects on intraoperative and postoperative characters. The results of the current study of stone characteristics were consistent with those of the prospective study [24]. A higher volume of stone is responsible for the worst intraoperative and postoperative conditions.

The current study excluded patients with ASA status of grade III. The major complications can be increased by 58% and the minor complications can be increased by 49% after surgeries if patients have preoperative ASA ≥ grade III [25]. Therefore, to standardize data, the current study included patients if they had ASA grade I or II (patients without significant systemic illness).

The study covers a topic that is normally not much studied in the urology field but there are several limitations of the study that have to be reported, for example, a monocentric retrospective analysis, and lack of prospective, randomized trial. ASA scores and ages are not homogeneous among groups and it can affect the results (patients enrolled in the GA group were younger and higher in numbers with ASA grade I than those of the SA and the EA groups. These may create bias). Even though the vasodilation property of levobupivacaine has been reported [26], the study did use bupivacaine for spinal anaesthesia. Different surgeons may have different preferences for perioperative patient management.

In the parent and the referring hospitals, types of anaesthesia were not fixed even with the high incidence of kidney stones, and many kidney stones are usually treated with ureterorenoscopy. This was determined sometimes by surgeons and sometimes by anaesthesiologists. Also, the differences in dilatation time would be due to surgeons’ different clinical practices [27]. Significant data about the experience of operators (anaesthesiologists/urologists) for each study group are not discussed. General anaesthesia is superior because it took approximately one-half of a minute (30–40s) less to reach the kidney stone. While this might be statistically significant with the high number of patients, but it is physiologically insignificant.

Conclusions

Epidural and spinal anaesthesia have advantages of fewer postoperative pain and better postoperative outcomes for flexible ureterorenoscopy. However, general anaesthesia facilitates early dilatation of ureters and access to the stone. This study suggests general anaesthesia for flexible ureterorenoscopy if there is no contraindication. However, the potential confounders (age, the American Society of Anaesthesiologists grade, experience of providers) were not taken into account in the data analysis stage. Such analysis may reveal that there was no real significant effect of any of the anaesthesia techniques studied. Also, the statistically significant differences found to reach the kidney stone are a half minute, which is physiologically insignificant.

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Author contributions

All authors have read and approved the manuscript for publication. HC and XW contributed equally to the conceptualization, literature review, software, methodology, and resources of the study. XC contributed to conceptualization, supervision, resources, methodology, data curation, and formal analysis of the study. WC contributed to investigation, conceptualization, resources, methodology, literature review of the study, draft, and edited the manuscript for intellectual content. All authors agree to be accountable for all aspects of work ensuring integrity and accuracy.

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ORCID

Haoliang Cai http://orcid.org/0000-0002-0356-3648
Xiaohui Wu http://orcid.org/0000-0003-0228-4070
Data availability statement

The datasets were used and analysed during the current study available from the corresponding author on reasonable request.

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