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Original Article

Use of the flexible vacuum-assisted ureteral access sheath combined with flexible ureteroscope for patients with large renal stones

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Abstract: Objective: To explore the effects and safety of the flexible vacuum-assisted ureteral access sheath combined with a flexible ureteroscope for the treatment of large renal stones over 3 cm. Methods: In this retrospective study, 122 patients with kidney stones (stone diameter ≥ 3 cm) admitted to our hospital from January 2018 to December 2022 were selected as the study subjects. According to different surgical methods, these patients were divided into an observation group and a control group, with 61 cases in each group. Patients in the control group were treated with the conventional negative pressure-assisted ureteral access sheath combined with flexible ureteroscope, while those in the observation group were treated with the flexible vacuum-assisted ureteral access sheath combined with flexible ureteroscope. The perioperative indexes, stone-free rate, usage rate of basket extraction, inflammation level, renal functional indexes, and incidence of postoperative complications were evaluated and compared between the two groups. Results: The extubation time, rate of multiple operations, and surgery cost in the observation group were significantly less than those of the control group (all $P < 0.05$), but the operation time was longer in the observation group than that of the control group ($P < 0.05$). The stone-free rate at 3 days after surgery in the observation group was higher than that of the control group, while the usage rate of basket extraction of the observation group was significantly less than that of the control group (all $P < 0.05$). The postoperative levels of C-reactive protein (CRP) and Interleukin (IL)-6 were significantly lower, while the level of IL-10 was significantly higher in the observation group than in the control group (all $P < 0.001$). The levels of renal functional indexes such as CysC, Scr, and KIM-1 in the observation group were lower than those of the control group (all $P < 0.05$). The total incidence of postoperative complications in the observation group was 8.20%, which was lower than 24.59% in the control group ($P = 0.014$). Moreover, postoperative sleep quality was better, and the comfort score was higher in the observation group than that of the control group (all $P < 0.001$). Conclusion: The flexible vacuum-assisted ureteral access sheath combined with flexible ureteroscope is effective in the treatment of large renal stones over 3 cm, and may improve the perioperative indexes, postoperative sleep quality and comfort, increase the stone-free rate, alleviate the inflammation levels and kidney functional injury, and reduce the incidence of complications.

Keywords: Renal stone, flexible ureteroscopy, ureter access sheath, kidney function, inflammatory factor, complication

Introduction

Kidney stones are a common urological condition, and with changes in diet and lifestyle, their incidence has been increasing each year, with cases appearing at progressively younger ages [1, 2]. Kidney stones can cause symptoms such as pain and hematuria, and without timely treatment, they may lead to kidney atrophy, renal failure, and other serious complications, harming quality of life [3, 4]. Therefore, early and effective removal of stones is essential. Currently, surgical treatment is the primary approach for patients with kidney stones, with ureteral lithotripsy commonly used due to its minimal invasiveness, high stone-free rate, and other advantages [5, 6]. However, previous studies indicate limitations in traditional ureteral sheaths, such as their inability to reach the junction between the renal pelvis and ureter when dealing with large stones, as well as challenges in maintaining a clear field during stone

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fragmentation [7]. Additionally, some studies report a low initial stone-free rate, with residual stone fragments that may require additional procedures to achieve a satisfactory outcome [8]. These findings highlight a need for improvement in the overall effectiveness of the traditional ureteral sheath.

With continuous advancements in medical technology, the introduction of the flexible vacuum-assisted ureteral access sheath offers a novel approach for treating patients with large renal stones. Research indicates that the flexible tip of this sheath can bend along with the flexible ureteroscope, allowing access to targeted calyceal areas while simultaneously crushing and suctioning stones [9]. One study also reported that the flexible vacuum-assisted ureteral access sheath could improve the one-time lithotripsy rate [10]. Further studies suggest it achieves better efficacy in patients with kidney stones between 2-3 cm [11, 12]. However, its effectiveness for treating larger stones (≥ 3 cm) remains uncertain, and there are limited studies comparing the flexible vacuum-assisted sheath with conventional negative pressure-assisted ureteral sheaths in treating renal stones over 3 cm. In this context, this clinical study aims to assess the efficacy and safety of the flexible vacuum-assisted ureteral access sheath combined with a flexible ureteroscope for treating large renal stones, evaluating perioperative metrics, stone-free rates, inflammation markers, renal function, and complications. This research is valuable for providing guidance for treating large renal stones.

Materials and methods

General information

In this retrospective study, patients admitted to the department of Urinary Surgery, The First People's Hospital of Jiashan for the large renal stones from January 2018 to December 2022 were included. This study was approved by the Ethics Committee of The First Peoplecess sheath comJiashan (Approval number: No. 2021-077).

Inclusion criteria: (1) Patients met the diagnostic criteria for renal stones, with a stone diameter of ≥ 3 cm confirmed by CT scan [13]; (2) Patients were classified as American Society of Anesthesiologists (ASA) Grade I-II; (3) Patients had not received prior treatment for renal stones before this study; (4) Patients were cooperative with study procedures, and clinical data were complete. Exclusion criteria: (1) Patients with urethral malformations, ureteral stenosis, or similar conditions; (2) Patients with abnormal renal anatomical structures, such as medullary sponge kidney or horseshoe kidney; (3) Patients with a preoperative urinary tract infection that could not be controlled; (4) Patients with serious systemic diseases affecting surgical outcomes; (5) Patients with malignant tumors or mental health disorders.

A total of 122 patients with large renal stones were included in this study based on the inclusion and exclusion criteria, and their clinical trial data were retrospectively analyzed. The patients were divided into two groups according to the surgical method: a control group and an observation group, with 61 patients in each group. All patients underwent lithotripsy by ureteroscopy; those in the control group were treated with a conventional vacuum-assisted ureteral access sheath, while patients in the observation group received treatment with a flexible vacuum-assisted ureteral access sheath.

Methods

All surgeries were performed by the same group of surgeons. The treatment in the observation group followed a standardized procedure for the flexible vacuum-assisted ureteral access sheath combined with a flexible ureteroscope. (1) All patients underwent general or lumbar anesthesia and were positioned in lithotomy. An F8/9.8 ureteroscope was inserted into the bladder under direct visualization, where a COOK guidewire was placed in the ureter, allowing retrograde insertion of the ureteroscope along the guidewire up to the ureteropelvic junction. (2) The ureteroscope was withdrawn, and the flexible vacuum-assisted ureteral access sheath (Fr11, 36/46 cm) was placed along the guidewire. The disposable Pusen ureteroscope was then used to examine the renal pelvis and calyces to assess stone location and size. (3) Using the ureteroscope's up-and-down bending controls, the flexible tip of the vacuum-assisted sheath was maneuvered passively until both sheath and ureteroscope reached the targeted renal calyceal site. (4) Lithotripsy was performed using a Lumenis titanium laser (200 μm), with energy parameters set to 1.0-1.2 J and 20-24 Hz. The perfusion pump pressure was set at 120-130 mmHg, with a flow rate of 200-300 mL/min. During lithotripsy, fine stone fragments were suctioned through the sheath gap, while slightly larger fragments were either further fragmented and suctioned through repeated withdrawals and negative pressure suction or removed using a basket extractor. The surgeons aimed for one-time lithotripsy in each operation. (5) After confirming satisfactory stone clearance by means of scope examination, a 6F ureteral stent and an 18F triple-lumen catheter were left in place. A CT scan of the urinary system was performed three days post-surgery to confirm the absence of residual stones. If stone clearance was confirmed, the ureteral and stent tubes were removed.

For patients in the control group, a Veli negative pressure suction ureteral sheath (Fr11, 36/46 cm) was used, positioned at the renal pelvis-ureter junction during lithotripsy. Stones were pulverized as thoroughly as possible, with larger fragments removed using a 2.2F COOK basket extractor. The remaining procedures were identical to those followed for the observation group, with ureter and ureteral stent tubes removed 2-4 weeks after the operation.

In both groups, additional procedures, such as extracorporeal or endoluminal lithotripsy, were conducted depending on the size of any residual stones identified in postoperative assessments.

Outcome measures

(1) Perioperative indexes: Perioperative metrics, including operation time, tube removal time (ureter or ureteral stent tube), rates of additional surgical sessions, hospital stay duration, and operation cost, were analyzed and compared between the control and observation groups.

(2) Stone-free rate: The stone-free rate was assessed at 3 days and 4 weeks post-surgery for both groups. Urological CT scans determined stone clearance, defined as the absence of residual stones or residuals less than 4 mm in diameter. Additionally, the utilization rate of basket extraction was compared between the two groups.

(3) Inflammatory factors: The levels of inflammatory markers were measured before surgery and at 3 days post-surgery. A 3 mL sample of fasting venous blood was collected from each patient, and enzyme-linked immunosorbent assay (ELISA) was used to measure levels of C-reactive protein (CRP) (Lot number: PC190, Beyotime, China), interleukin-6 (IL-6) (Lot number: PI330, Beyotime, China), and IL-10 (Lot number: PI528, Beyotime, China). All assays followed the provided kit instructions.

(4) Renal function indexes: Renal function markers, including cystatin C (CysC), serum creatinine (Scr), and kidney injury molecule-1 (KIM-1), were evaluated preoperatively and at 3 days post-surgery. Blood samples (4 mL of fasting venous blood) were collected, and serum was isolated through centrifugation. A fully automated biochemical analyzer (Type AU5800, Beckman Coulter, Inc., USA) was used to assess these markers.

(5) Postoperative complications: The incidence of complications such as hematuria, fever, pain, and the formation of stones was compared. The overall incidence of postoperative complications was evaluated between the two groups.

(6) Postoperative sleep quality and comfort: One month after surgery, sleep quality and comfort were assessed. Sleep quality was evaluated with the Pittsburgh Sleep Quality Index (PSQI), which includes 7 dimensions and a total score range of 0-21, with higher scores indicating poorer sleep quality. Insomnia symptoms and severity were assessed using the Athens Insomnia Scale (AIS), with a score of 4-6 suggesting mild insomnia and scores above 6 indicating more severe insomnia. Comfort levels were measured using the Bruggrmann Comfort Scale (BCS), which ranges from 0 to 4, with higher scores indicating greater comfort.

Statistical methods

Data analysis in this study was conducted using SPSS software (IBM, USA), version 23.0. Measured data were reported as mean ± standard deviation (SD). Comparisons between the two groups were performed using independent samples t-tests, while comparisons within groups before and after treatment were analyzed using paired t-tests. Counted data were presented as case/percentage [n (%)] and were analyzed between groups using Chi-square te-

Table 1. Comparison of general information between the two groups [Mean ± SD, *n* (%)]

Group		Observation group (n = 61)	Control group (n = 61)	χ^2/t value	*P* value
Gender	Male	41 (67.21)	38 (62.30)	0.323	0.570
	Female	20 (32.79)	23 (37.70)		
Age (years)		52.67 ± 8.48	53.15 ± 8.63	0.310	0.757
BMI (kg/m^2)		23.15 ± 2.95	23.20 ± 2.77	0.097	0.923
ASA classification	I level	23 (37.70)	26 (42.62)	0.307	0.580
	II level	38 (62.30)	35 (57.38)		
RUSS scores		4.02 ± 0.56	3.99 ± 0.67	0.268	0.789
CT values of stones (Hu)		986.69 ± 136.07	992.74 ± 105.38	0.275	0.784
Maximum diameter of stones (cm)		3.95 ± 0.40	3.97 ± 0.43	0.266	0.791
Number of stones	Single	24 (39.34)	25 (40.98)	0.034	0.853
	Multiple	37 (60.66)	36 (59.02)		
Location of stones	Upper and middle calices	38 (62.30)	40 (65.57)	0.142	0.706
	Lower calices	23 (37.70)	21 (34.43)		

Note: BMI: body mass index; RUSS: Resurlu-Unsal Stone Score; ASA: American Standards Association; CT: computerized tomography.

Table 2. Comparison of perioperative indexes between the two groups [Mean ± SD, n (%)]

Group	Time of operation (min)	Extubation time (Weeks)	Rates of multiple operations [*n* (%)]	Hospital stays (d)	Surgery cost (10,000 yuan)
Observation group (n = 61)	98.45 ± 11.61	2.52 ± 0.63	6 (9.84)	3.58 ± 0.67	2.12 ± 0.39
Control group (n = 61)	85.27 ± 9.58	3.83 ± 0.74	17 (27.87)	3.66 ± 0.70	2.47 ± 0.52
χ^2/*t* value	6.839	10.528	6.483	0.645	4.206
P value	< 0.001	< 0.001	0.011	0.520	< 0.001

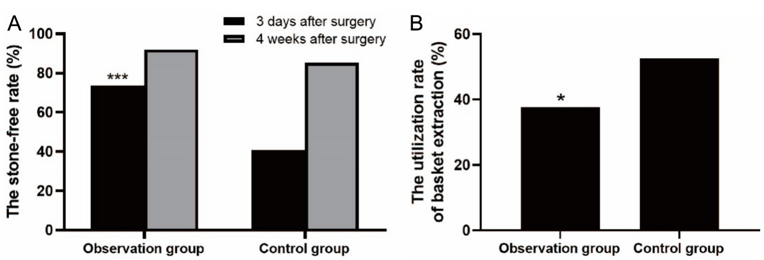

Figure 1. Comparison of the stone-free rate and the usage rate of basket extraction between the two groups. ***P < 0.001 vs. control group at 3 days after surgery. *P < 0.05 vs. control group.

sts. A *p*-value of < 0.05 was considered significant.

Results

Comparison of general information

Table 1 shows that there were no significant differences between the control and observation groups in terms of sex, age, body mass index, ASA classification, RUSS scores, CT values of stones, maximum stone diameter, number of stones, or stone locations (all P > 0.05), indicating comparability between the groups.

Comparison of perioperative indexes

In terms of hospital stay, there were no statistical differences between the two groups. However, in the observation group, the extubation time, rate of multiple session operations, and surgery cost were 2.52 ± 0.63 weeks, 9.84%, and 2.12 ± 0.39 ten thousand yuan, respectively, all of which were significantly less than those in the control group. Conversely, the operation time in the observation group was longer than that in the control group, with significant differences observed, as shown in **Table 2**.

Comparison of the stone-free rate and the usage rate of basket extraction

As shown in **Figure 1**, the stone-free rate at 3 days post-surgery in the observation group was significantly higher compared to the control group, with a notable difference (P < 0.001). However, there were no significant differences

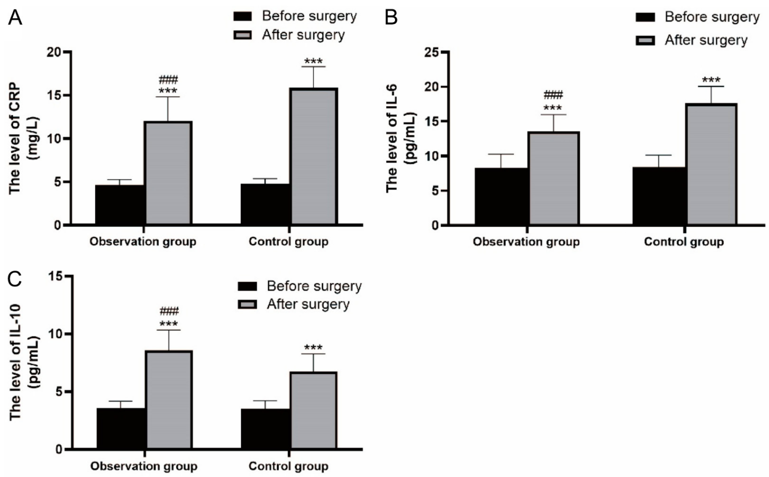

Figure 2. Comparison of inflammatory levels between the two groups. A: CRP level; B: IL-6 level; C: IL-10 level; ***P < 0.001 vs. before surgery in the same group; ###P < 0.001 vs. after surgery in the control group. Note: CRP: C-reactive protein; IL-6: Interleukin-6; IL-10: Interleukin-10.

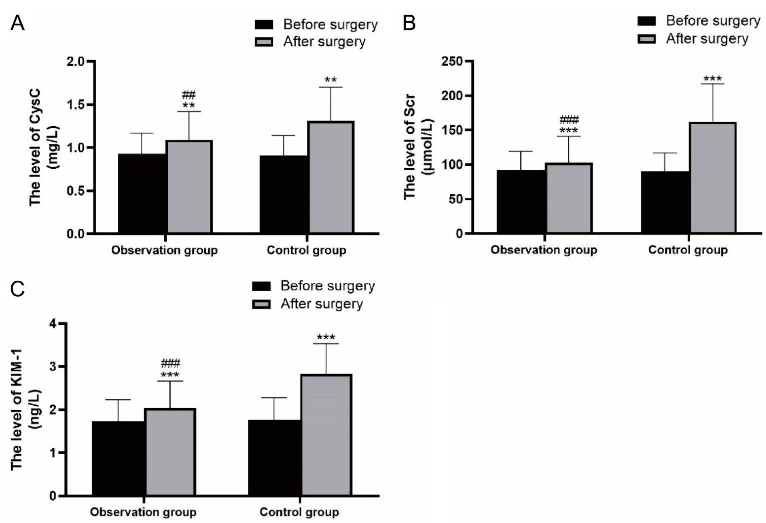

Figure 3. Comparison of renal function indexes between the two groups. A: CysC level; B: Scr level; C: KIM-1 level; ***P < 0.001 vs. before surgery in the same group; ###P < 0.001 vs. after surgery in the control group. **P < 0.001 vs. before surgery in the same group; ##P < 0.001 vs. after surgery in the control group. Note: CysC: Cystatin C; Scr: Serum creatinine; KIM-1: Kidney injury molecule-1.

in the stone-free rate at 4 weeks post-surgery between the two groups. Additionally, the utilization rate of basket extraction in the observation group was significantly lower than in the control group (2.17 ± 0.80 vs. 37.7%, P < 0.05).

Comparison of inflammatory factors between the two groups

As shown in **Figure 2**, there were no significant differences in the serum levels of CRP, IL-6, and IL-10 between the control and observation groups before treatment (P > 0.05). However, the levels of CRP and IL-6 after surgery in the observation group were significantly lower than those in the control group (all P < 0.001). Additionally, the post-surgery IL-10 level in the observation group was significantly higher than that in the control group (all P < 0.01).

Comparison of renal function indexes between the two groups

As shown in **Figure 3**, there were no significant differences in the renal function markers, including CysC, Scr, or KIM-1, between the control and observation groups before surgery (P > 0.05). After surgery, the levels of CysC, Scr, and KIM-1 in both groups were significantly higher than their pre-surgery levels (all P < 0.05). Additionally, the levels of post-surgery CysC, Scr, and KIM-1 in the observation group were markedly higher than those of the control group (all P < 0.05).

Comparison of incidence of postoperative complications

As shown in **Table 3**, in the control group, there were three cases of hematuria, four cases of fever, five cases of pain, and three cases of stone formation. In contrast, the observation group had one patient with hematuria, one patient with fever, two patients with pain, and one patient with stone formation. The overall incidence of postoperative complications in the observation group was significantly lower than that of the control group (8.20% vs. 24.59%, P = 0.014).

Comparison of the sleep quality and comfort

As shown in **Figure 4**, there were no significant differences in the PSQI, AIS, and BCS scores

Table 3. Comparison of incidence of postoperative complications between the two groups [n (%)]

Group	Hematuria	Fever	Pain	Formation of stone steps	Overall incidence
Observation group (n = 61)	1 (1.64)	1 (1.64)	2 (3.28)	1 (1.64)	4 (8.20)
Control group (n = 61)	3 (4.92)	4 (6.56)	5 (8.20)	3 (4.92)	15 (24.59)
χ^2 value					5.980
P value					0.014

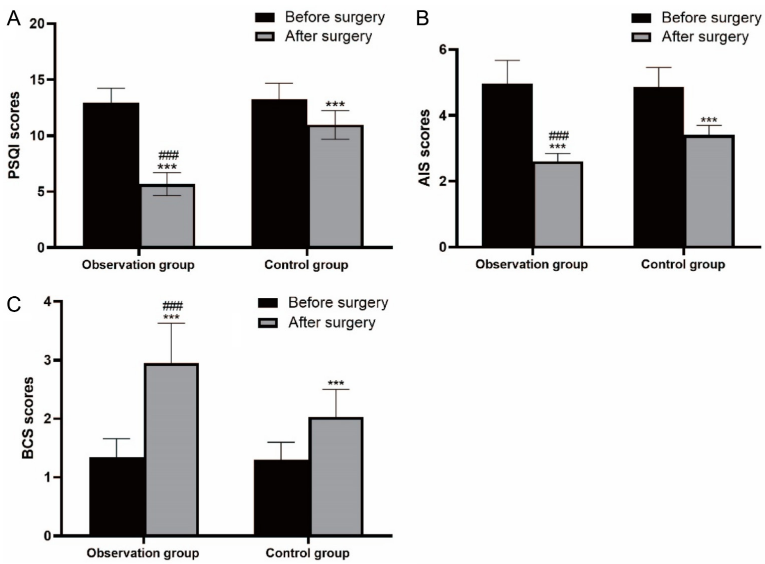

Figure 4. Comparison of the sleep quality and comfort between the two groups. A: PSQI scores; B: AIS scores; C: BCS scores; ***P < 0.001 vs. before surgery in the same group; ###P < 0.001 vs. after surgery in the control group. Note: PSQI: Pittsburgh Sleep Quality Index; AIS: Athens Insomnia Scale; BCS: Bruggrmann comfort scale.

between the control and observation groups before treatment (P > 0.05). However, the PSQI and AIS scores after surgery in the observation group were significantly lower than those of the control group (all P < 0.001). Additionally, the BCS scores after surgery in the observation group were significantly higher than those of the control group (P < 0.01).

Discussion

Kidney stones are a common type of urinary stone, with symptoms that typically include hematuria and pain. As the condition progresses, it can lead to urinary tract obstruction, resulting in complications such as urinary tract infections and hydronephrosis. In severe cases, kidney stones may even cause loss of renal function, making early lithotripsy treatment essential for affected patients [14, 15]. Flexible ureteroscopy has been regarded as the best surgical modality for patients with kidney stones ≤ 3 cm in diameter. However, for patients with larger stones (≥ 3 cm), the use of titanium lasers can damage the flexible ureteroscope during the procedure due to prolonged bending, which may impact its normal function and increase the operational demands on surgeons. Nevertheless, ongoing research has broadened the indications for flexible ureteroscopy. Some reports indicate that using phased operations, negative pressure suction lithotripsy devices, and high-performance lasers can yield better outcomes for patients with larger renal stones undergoing flexible ureteroscopy [16, 17].

Negative pressure ureteral sheaths are a type of flexible ureteroscopy consumable that has gained significant attention in recent years. Compared to traditional ureteroscopy sheaths, these devices feature negative pressure suction, allowing them to effectively remove stone dust during laser lithotripsy. This capability helps maintain a clear surgical field, thereby improving the safety of the procedure [18, 19]. However, the head end of standard negative pressure suction ureteral sheaths can only reach the ureteral connection of the renal pelvis, which limits their overall negative pressure suction capacity. As a result, most patients with large-diameter kidney stones typically require two or more stages of surgery to achieve a better stone removal rate. Unfortunately, the increased number of surgical procedures can exacerbate damage to the patient's body.

The flexible vacuum-assisted ureteral access sheath has been developed based on traditional negative pressure ureteral sheaths, featuring a bendable head end within 10 cm and a sparse metal support ring that provides adequate support while bending, with a bending angle reaching up to 160° [20]. Some studies have demonstrated that the flexible vacuum-assisted ureteral access sheath significantly improves stone clearance compared to traditional ureteral sheaths and shows promising prospects for clinical application [10]. It has also been reported that this sheath is particularly effective for treating patients with renal stones ≤ 2 cm, especially those with lower calyceal stones, resulting in higher postoperative stone clearance rates [20]. However, there are fewer reports on the application of the flexible vacuum-assisted ureteral access sheath in patients with larger renal stones (≥ 3 cm). A study conducted in China used the flexible vacuum-assisted ureteral access sheath in patients with renal stones ≥ 2 cm, with an average stone diameter of 3.4 ± 1.64 cm. Their study indicated that the flexible vacuum-assisted ureteral access sheath enabled more efficient and safe stone fragmentation [21]. Another clinical trial reported that applying the flexible vacuum-assisted ureteral access sheath in patients with renal stones ≥ 3 cm resulted in a 72.73% clearance rate in the first phase, along with a lower incidence of postoperative fever and stone step formation [20]. However, there remain relatively few similar reports.

The results of this study indicated that patients on whom the the flexible vacuum-assisted ureteral access sheath was used experienced longer operative times. This extension may be attributed to the sheath's ability to achieve more effective stone clearance rates intraoperatively, which, to some extent, prolonged the surgical duration. However, our study also found that patients with the flexible vacuum-assisted ureteral access sheath had shorter tube removal time, fewer multiple surgical sessions, reduced hospital stays, and lower surgical costs. Notably, the stone clearance rate at 3 days postoperatively was 73.77%, suggesting that this approach significantly enhances stone clearance efficacy. This effectiveness is primarily due to the flexible vacuum-assisted ureteral access sheath's capacity to harness local eddy currents during stone removal, facilitating simultaneous stone crushing and suction. Additionally, the perfusion fluid can reflux through the gap between the ureteroscope and the sheath, increasing negative pressure suction, ensuring a clear surgical field, and further enhancing stone fragmentation. This reduces the likelihood of patients needing multiple surgical sessions, consequently shortening the duration of tube retention and allowing for earlier tube extraction.

Furthermore, regarding costs, the price of the traditional negative pressure ureteral sheath is comparable to that of the flexible vacuum-assisted ureteral access sheath, meaning that this innovation does not impose an additional economic burden on patients. In cases involving the traditional negative pressure ureteral sheath, basket extractions are often necessary for stones located in less accessible calyces. In contrast, the flexible vacuum-assisted ureteral access sheath can better reach target calyces, thereby decreasing the reliance on basket extractions during the procedure. The study's findings showed that the utilization rate of basket extractions in the observation group was significantly lower than in the control group. Additionally, reducing the number of subsequent operations can lower the overall surgical costs, further alleviating the economic burden on patients.

This study demonstrated that the postoperative inflammatory reaction was milder in patients using the flexible vacuum-assisted ureteral access sheath. This is primarily due to the negative pressure suction, which allows for the rapid discharge of perfusate through the circulation. This process not only effectively maintains stable intra-pelvic pressure but also simultaneously expels bacteria and endotoxins during lithotripsy, thereby alleviating the postoperative inflammatory response. During kidney stone surgery, factors such as surgical anesthesia, tracheal intubation, surgical trauma, and organ injuries serve as significant stressors, triggering a series of oxidative stress reactions that can disrupt the balance between oxidative and antioxidant systems [22]. Kidney function is particularly susceptible to damage from trauma, hypoxia, ischemia, and oxidative stress. Consequently, enhancing perioperative protection of kidney function has gained increasing attention from clinicians. Selecting reasonable and effective surgical approaches is crucial for protecting renal function [23]. In this study, serum CysC, Scr, and urinary KIM-1 levels were significantly elevated post-surgery in both groups, indicating that ureteroscopic lithotripsy adversely affected renal function during treatment. However, the levels of serum CysC, Scr, and urine KIM-1 in the observation group were lower than those of the control group, suggesting that the flexible vacuum-assisted ureteral access sheath caused less organ damage and was more beneficial in protecting renal function. These findings are consistent with results reported in other studies [24].

In terms of complications, the overall incidence of postoperative complications, including hematuria, fever, pain, and stone formation, was lower in patients receiving the flexible vacuum-assisted ureteral access sheath compared to the control group. The primary reasons for this difference are as follows: traditional negative pressure ureteral sheaths have a lower one-time stone removal rate, leading to residual small stones in the kidney, which can increase the complication rate. Additionally, prolonged retention of ureteral stent tubes and catheters contributes to complications such as hematuria. In contrast, the flexible vacuum-assisted ureteral access sheath can mitigate these complications due to its higher one-time stone removal rate and shorter retention time for the tubes. Another study [25] also indicated that the flexible vacuum-assisted ureteral access sheath was more effective in reducing complications. Therefore, the combination of the flexible vacuum-assisted ureteral access sheath with flexible ureteroscopy is both safe and effective for patients with renal stones measuring ≥ 3 cm.

Kidney stones themselves do not have a direct effect on sleep when the condition is stable [26]. However, during episodes of kidney stone disease, they can cause back pain, nausea, vomiting, and even urinary tract irritation, which can significantly disrupt sleep quality. This may lead to difficulties in falling asleep or shorter sleep duration, ultimately impacting the patient's overall quality of life and health [27]. In this study, results indicated that the PSQI and AIS scores after surgery in the observation group were lower than those in the control group, while the BCS score in the observation group was higher than that in the control group (all $P < 0.001$). The flexible vacuum-assisted ureteral access sheath combined with flexible ureteroscopy, aims to enhance patients' quality of life by removing stones and alleviating the symptoms they cause. Following the successful procedure, patients experienced significant relief from symptoms such as pain and irritation caused by the stones, leading to improved sleep quality. Specifically, after surgery, patients reported less pain, no longer waking up at night due to discomfort, and experiencing more restful sleep. Additionally, the removal of the stones alleviated urinary tract irritation symptoms, allowing patients to avoid issues like frequent urination and urgency that disrupt sleep. However, it is important to note that the surgery itself involves some degree of trauma. Postoperatively, patients may experience transient discomfort due to surgical trauma and anesthesia reactions, which can affect their sleep. Typically, this effect is temporary, and patients' sleep quality and comfort gradually improve with postoperative recovery and pain management. These findings align with previous studies [28].

However, this study has some limitations, including a small overall sample size and a lack of long-term follow-up on recurrence. Future research should focus on these aspects to conduct more in-depth studies.

In conclusion, compared to traditional ureteral sheaths, the flexible vacuum-assisted ureteral access sheath combined with flexible ureteroscopy demonstrates significant benefits in treating patients with large kidney stones (≥ 3 cm). This approach can enhance stone removal rates, effectively alleviate postoperative inflammatory reactions and renal function injuries, and reduce the risk of complications, all while offering improved efficacy and safety.

Disclosure of conflict of interest

None.

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