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Original research

APPLICATION OF VACUUM - ASSISTED URETERAL ACCESS SHEATH IN RETROGRADE INTRARENAL SURGERY: AN INITIAL EXPERIENCE OF 48 CASES

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ABSTRACT

Objectives: *Reporting our initial experience of 48 cases in application of vacuum-assisted ureteral access sheath in the retrograde intrarenal surgery.*

Methods: *Forty - eight patients who underwent retrograde intrarenal surgery at Department of Urology, Hue Central Hospital between May 2023 and May 2024 were evaluated retrospectively. The vacuum - assisted ureteral access sheath was applied in the procedure. Demographics, laboratory tests, peri - and postoperative and one-month follow-up results were analysed.*

Results: *The mean stones size was 14.3 ± 4.9 mm. 77.1% of cases had stones located in the lower calyx. The mean operative time was 42.9 ± 17.1 minutes. The 1 - month post - operative stone - free rate was 89.6%. Two patients experienced post - operative fever. The average length of hospital stay was 3.06 ± 1.04 days. There was no unplanned readmission.*

Conclusions: *Retrograde intrarenal surgery with vacuum-assisted ureteral access sheath is a safe and effective procedure, which can achieve excellent stone clearance.*

Keywords: *Kidney stones, ureteral access sheath, retrograde intrarenal surgery, RIRS, vacuum-assisted ureteral access sheath.*

I. INTRODUCTION

Urolithiasis is not only among the most common urological diseases with an incidence of 1-20% worldwide [1], but also a significant contribution of morbidity, affecting approximately 1-15% of the global population [2]. During the last decades, the variety of minimally invasive techniques have invented and applied in treatment of this disease. According to American Urological Association (AUA) and European Association of Urology (EAU) guideline, retrograde intrarenal surgery (RIRS) using flexible ureteroscope (fURS) was preferred treatment for kidney stones smaller than 2 centimetres in diameter or extracorporeal shock wave lithotripsy failure [3].

This procedure offered the advantages of reduced invasiveness, less haemorrhage, and shorter hospital stay. RIRS has been considered as an effective approach for managing renal and ureteral stones smaller than 2 cm, exhibiting a low complication rate and superior preservation of renal parenchymal function when compared to percutaneous nephrolithotomy (PCNL) [4].

Nevertheless, intrarenal pressure regulation and the presence of residual fragments persist as significant limitations of RIRS [5]. Elevated intrarenal pressure exceeding 40 mmHg may precipitate pyelovenous backflow, potentially exacerbating urinary tract infections (UTI), particularly in cases involving infectious upper ureteral stones [6]. Moreover, the

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clearance of residual fragments is a time-dependent process governed by self-elimination, which could potentially result in recurrent infection or urinary tract obstruction [7].

Recently, a novel vacuum-assisted ureteral access sheath (VA-UAS) has been invented to minimize these weaknesses of RIRS. In comparison with conventional UAS, this device had an oblique drainage tube that is constructed as a handle. This oblique drainage tube featured a longitudinal slit designed as a pressure-regulating vent. The primary benefits of this VA-UAS include its efficient reduction of intrarenal pressure and enhanced stone-free rates (SFR). The integration of fURS with VA-UAS has the potential to emerge as a novel therapeutic adjunct for RIRS. Since mid-2023, we have been applied this novel method in urolithiasis treatment at our center. In this study, we report our initial experience in using the novel VA-UAS combination with fURS.

II. MATERIAL AND METHODS

Patients with less than 2 cm renal stones referred to our center between May 2023 and May 2024 were considered for this study. We excluded patients who had a congenital renal anomaly, ureteropelvic junction obstruction, ureteral stricture, previous surgery, refractory infection, and pyonephrosis. This study has been approved by the Ethics Committee of Hue Central Hospital.

All patients underwent preoperative assessment including urine cultures, laboratory tests (including hemogram, general blood biochemistry, and basic coagulation profiles), and computed axial tomography (CT) with volumetric reconstruction to examine the kidney stone and its relationship with the urinary tract. Demographic variables (such as age, associated comorbidities, renal anomalies, prior lithiasis treatment, antiplatelet or anticoagulant therapy), kidney stone characteristics (location, size, and number of stones), as well as perioperative and postoperative parameters (prior double J stent placement, surgical duration, complications, length of hospitalization, and readmissions) were evaluated. Criteria for stone clearance: no residual stones, or residual stones < 4 mm in diameter (based on abdominal ultrasound and KUB film), without typical symptoms [8].

Surgical techniques: Under general anaesthesia, the patient was placed in a lithotomy position for retrograde endoscopic access. Prior to fURS, a semirigid ureteroscope was utilized to examine the ureter and remove double-J stents (if it it was placed preoperatively). Next step is assessment of ureteral anatomy and any abnormalities (such as lack of distensibility, loops, or kinks) that could hinder sheath passage and intramural ureter dilation, thus facilitating sheath passage. A 0.032-inch loach guidewire was introduced into the upper urinary tract, followed by an 12/14 Fr VA-UAS (Figure 1) inserted into the upper ureter. All procedures were conducted using an unique model of flexible ureteroscopes (9.5Fr Uscope PU3022a, Pusen™). Holmium laser fragmentation was performed using a Holmium High Power Laser 60W with 200µm fibers and its setting was between 1 – 1.2 J and 20 Hz. Then stone fragments were flushed out of the body by water pressure from a perfusion pump. Double-J stent and urinary catheter were routinely indwelled after surgery. The urinary catheter was removed 24 hours after the surgery. Postoperatively, patients received standard antibiotic therapy and underwent imaging studies such as KUB, ultrasound, or CT scan within three days and one month to assess SFR and the position of the double-J stent. The double-J stent was typically removed one month after the operation.

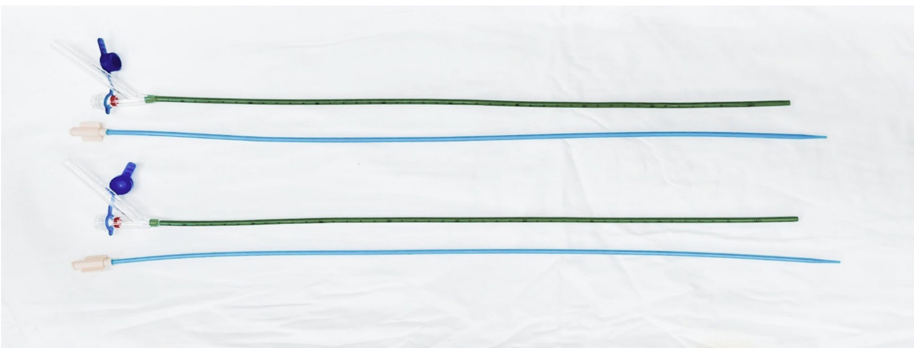

Figure 1: Vacuum - assisted ureteral access sheath.

III. RESULTS

Pre-operative parameters like the patient's demographics and stone characteristics were summarized in Table 1. A total of 48 patients who underwent RIRS combination with VA-UAS was recorded. The median age was 60.2 ± 11.7. Among them, 60.4% were male. Additionally, 62.5% of patients admitted to the hospital with flank pain, while 31.1% had residual stone fragments following previous surgeries or unsuccessful procedures. Most cases (77.1%) involved stones located in the lower calyx. 7 out of 48 cases had multiple stone, with a median stone size of 14.3 ± 4.9 mm. Additionally, 60.4% of cases presented without hydronephrosis (Table 1). The median ratio of the volume of water drained by VA-UAS to the total volume was 63.7% ± 12.1%. The median operative time was 42.9 ± 17.1 minutes. No complications were reported during the surgical procedures. In 4.2% of cases, postoperative fever occurred. The SFR after one month was 89.6% (as shown in Table 2 and Table 3).

Table 1: Preoperative characteristics

Characteristics	Results
Age (years)	60.2 ± 11.7
Male/Female	29/19
Reason for hospitalization (%)	
Flank pain	62.5 %
Residual fragments after PCNL	4.2 %
Residual fragments after URS	14.6 %
Residual fragments after ESWL	4.2 %
Residual fragments after open surgery	8.3 %
Others	6.3 %
Location of stones (%)	
Lower calyx	77.1%
Middle calyx	39.6 %
Upper calyx	12.5%
Renal pelvis	8.3 %
Upper ureter	6.25%
Solitary/multiple stones	41/7
Stone size (mm in CT scan)	14.3 ± 4.9 mm
Grading of Hydronephrosis (%)	
No	60.4%
Grade 1	31.3%
Grade 2	8.3%

* Extracorporeal shock wave lithotripsy (ESWL), retrograde intrarenal surgery (RIRS), and percutaneous nephrolithotomy (PCNL), Ureterorenoscopy (URS).

Table 2: Operative characteristics

Characteristics	Results
The ratio of volume of water drained by VA-UAS to total volume (%)	
< 50%	27.1%
50 - 75%	52.1%
> 75%	20.8%
Median	63.7% ± 12.1%
Operative time (minutes)	42.9 ± 17.1
Complications during surgery	
Bleeding (lead to stop the procedure)	0 %
Bleeding (need a blood transfusion)	0 %
Ureteral injury	0 %

Table 3: Postoperative and 1-month follow-up characteristics

Characteristics	Results
Early postoperative complications (%)	
Postoperative fever	4,2%
Sepsis	0%
Bleeding (need a blood transfusion)	0%
Perinephric fluid collections	0%
Hospital stays (Days)	3,06 ± 1,04
1-month follow-up SFR (%)	89,6 %

IV. DISCUSSION

Urolithiasis represents a prevalent urological condition. Surgical intervention for this disease is geared towards complete removal, obstruction relief, and infection control, while minimizing complications. Recent advancements in technology and equipment have propelled the evolution of surgical approaches for urological stones from traditional open surgery to various minimally invasive techniques, prominently including ESWL, RIRS, and PCNL [9]. According to AUA and EAU guidelines, RIRS are recommended as an ideal approach to remove < 2 cm renal and upper ureteral stones [3].

Despite advancements, several challenges persist in retrograde intrarenal surgery (RIRS), notably the management of intrarenal pressure (IRP) during the procedure and the handling of residual small stone fragments postoperatively [10]. Elevated IRP can trigger pyelovenous backflow, potentially leading to sepsis through bacterial and endotoxin translocation into the bloodstream [6]. Attaining optimal IRP often involves reducing irrigation flow, which may compromise surgical visualization and lithotripsy effectiveness. Fragment extraction during RIRS commonly employs a basket, a process that can be time-consuming and may not thoroughly eliminate all stone fragments, particularly those smaller than 2 mm [11]. Recently, various types of ureteral access sheaths (UAS) have emerged and greatly improved the efficiency, including a vacuum-assisted UAS (VA-UAS) utilized in this study.

In our study with the use of VA-UAS, there were no intra or postoperative complications reported, either septic or traumatic in nature except for only 2 cases of postoperative fever that resolved after 24 hours. The incorporation of suction during RIRS has been shown to reduce the postoperative systemic inflammatory response, as low IRP and temperature help mitigate the adverse effects of pyelovenous and pyelolymphatic reflux. This observation was corroborated by our study's absence of infectious complications, despite the relatively small cohort size.

Moreover, by adding oblique suction, our ability to maintain clear vision was facilitated by simultaneous aspiration of the dust, which prevented the "snow globe" effect commonly encountered during the procedure [12]. Besides, it can provide continuous aspiration effect towards specific calyx or fragments, thus made the fragments being washed out by the vortex flow much more efficiently. VA-UAS demonstrated high efficiency in fragment removal, contributing to an impressive stone-free rate of 89.6% in our case series. This UAS variant seamlessly integrates with standard vacuum systems, offering ease of manipulation and a relatively steep learning curve.

Our current study possesses several limitations. It was conducted in a retrospective observational design, which may introduce bias into the results. Additionally, due to its status as our initial clinical experience, the sample size remained relatively small, rendering our study inadequate to definitively establish the superiority of the current technique over conventional approaches. To validate our hypothesis, larger-scale prospective comparative studies are warranted. Moreover, the majority of cases in our study were pre-stented to facilitate UAS insertion. The utilization of smaller caliber UAS in conjunction with novel endoscopes may help overcome this limitation in future investigations.

V. CONCLUSION

Our current study underscores the promise of utilizing VA-UAS in RIRS for upper urinary tract stones. This approach proves to be both safe and effective. However, to conclusively establish its superiority over conventional RIRS or PCNL, prospective randomized trials are necessary.

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