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Original Article

Improved laparoendoscopic single-site surgery for treatment of ureteral calculus and pelvis calculi: a single center study of 45 cases

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Abstract: Urinary stone disease (USD) has become a significant health issue worldwide and current open surgeries are rendered less satisfactory due to their impairments on the appearance of patients. Laparoendoscopic single-site surgery (LESS) is a technique capable of improving the cosmetic characteristics of open surgeries. In the current study, we applied an improved LESS method during the operation of ureterolithotomy or pyelolithotomy. 45 (53 sides) USD patients receiving ureterolithotomy or pyelolithotomy with LESS between May 2014 and June 2016 in Urology Surgery of the First People Hospital of Yunnan Province were included. The LESS technique was improved by cutting the length of trocar into 8 cm. Moreover, the inserting operation of Double-J (D-J) stent and incision suture were also modified in the current study to simplify the operation and to save the surgery time. Based on the analysis, ureterolithotomy or pyelolithotomy with LESS was successfully performed with all the patients. The average surgery duration was 97 min and the average intraoperative blood loss was 15 mL. The results showed that hydronephrosis was attenuated in all the patients and no ureterostenosis was recorded. The average Vancouver scar scale score of the incisions was 2.3 and no severe side effect was observed for patients in the cohort during the follow-up as long as 12 months. With the improvements on the one-port device, D-J stent insertion, and incision suture, the USD patients showed considerable recovery and satisfactory cosmesis without severe side effects after the surgeries.

Keywords: Double-J stent, laparoendoscopic single-site surgery, pyelolithotomy, suture, ureterolithotomy, urinary stone disease

Introduction

USD describes the presence of stones and calcification within the urinary tract [1]. The disorder has an estimated incidence of 5% in general population and an annual incidence of as high as 1% [2], ranking the first in hospitalized patients in urology. In the United States alone, USD costs over $2 billion each year from the public health system and patients for the proper management [3]. In China, more than 25% of patients depend on the hospitalization for the alleviation of symptoms associated with USD [4]. Thus, the disorder has become a significant health issue worldwide and the development of therapeutic strategies against USD receives lots of attention in recent years.

Currently, surgical management is the most commonly used strategy for handling USD. With the advancement in surgery techniques, the treatment of USD has achieved considerable improvements during the last 30 years. For example, modified optic lens systems and fiber-optic light sources enable the clinicians to have better visualization during surgeries [1]. More effective energy sources allow the increase in instrument flexibility and miniaturization, which leads to the development of percutaneous nephrolithotomy (PCNL) and ureteroscopic lithotripsy (URS) [5]. In addition, extracorporeal shock wave lithotripsy (ESWL) is developed for stone fragmentation without invasion of bodies [1]. However, the above methods may result in severe infection and avulsion in urinary tracts, and sometimes even hemorrhea and organ failures in patients [5]. Worse still, for USD patients with stone's diameter larger than 1.5 cm, high hardness pelvis, ureteral calculus or primary obstructive disease, non-invasive surgery methods are rendered less effective when compared with open surgeries such as ureterolithotomy

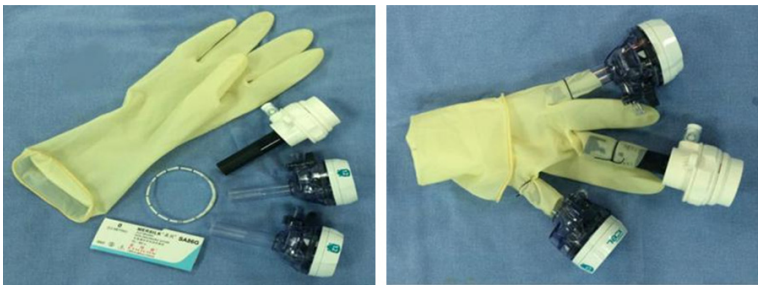

Figure 1. Illustration of the one-port device used in the current study. The length of trocar was cut to 8 cm.

[6]. Given the patients' needs for minimizing the impact of open surgeries on their body appearance, techniques that can increase the non-invasive feature of open surgeries is demanding prompt solution.

LESS is conceived as an evolutionary step beyond standard laparoscopy. Since introduced, the technique has been increasingly adopted by urologists worldwide [7, 8]. LESS may benefit USD patients in terms of surgery-related complications, recovery time, pain, and cosmesis [9, 10]. Theoretically, LESS can minimize skin incisions that are used to gain access into the abdominal or pelvic cavities [11, 12]. Over the last few years, many studies have reported the application of LESS in place of standard laparoscopic operations in urology and the surgery outcomes are at least comparable to that of standard laparoscopy [13, 14]. As a complement to the studies regarding LESS, the current study reported the successful performance of ureterolithotomy or pyelolithotomy with improved LESS in 45 USD patients.

Materials and methods

Patients

The study cohort consisted of 45 consecutive patients (53 sides) treated with LESS between May 2014 and June 2016 in Urology Surgery of the First People Hospital of Yunnan Province. All the patients were identified to be not available for treatments with ESWL, URP, and PCNL based on imaging and etiology detections or did not receive satisfactory outcomes after treatments with the above methods. The cohort included 12 males and 33 females, and had an average age of 35.5 (ranging from 16 to 59) years old and an average BMI of 22.4 (ranging from 17.2 to 26.4). The average size of stones was 2.5 (ranging from 1.5 to 5.5) cm in diameter. 20 patients had stones in the left sides of ureter, 17 in the right sides, and 8 in both sides. The study was approved by the Ethic Committee of the First People Hospital of Yunnan Province and all participants provided their written consents. The data did not contain any information that could identify the patients. All works were undertaken following the provisions of the Declaration of Helsinki.

Surgical procedures

A homemade single port device was prepared using F6 ureteral catheters, threads, and a sterile glove according to the study of Lee et al. [15] (**Figure 1**) with some modifications: trocar's length was cut to 8 cm. Stone positions were located using KUB method, and then patients were subjected to general anesthesia and placed in a flank position at a slanted angle of 70 degrees. A 3-cm incision was made in the avascular area of the affected side and the intra-abdominal CO_2 pressure was maintained at 15 mmHg. The single port device was inserted into the abdominal cavity through the incision. A 30-degree laparoscope was inserted into one of the three trocars, and flexible laparoscopic instruments and the Roticulator were inserted into the remaining two trocars. Within the peritoneum, the large intestine was retracted and the ureter was exposed and fixed. A longitudinal incision was made at the ureter or the renal pelvis, and the stones were removed with laparoscopic forceps. Subsequently, Double-J (D-J) stent was inserted into the incision using the improved method: briefly, the site for D-J stent insertion was previously marked using a 4-0 polyglactin and the soft flexible Angled tip of Zebra Guide Wire was placed into the D-J stent. Then the D-J stent was inserted using the guide wire and placed at the marked polyglactin right under the incision of ureter through the guid ewire. The D-J stent was pulled out through incision using the polyglactin. Then the drainage tube was placed through the incision and the incision was sutured. The detail illustrations of improved D-J insertion and suturing methods were shown in **Figure 2**.

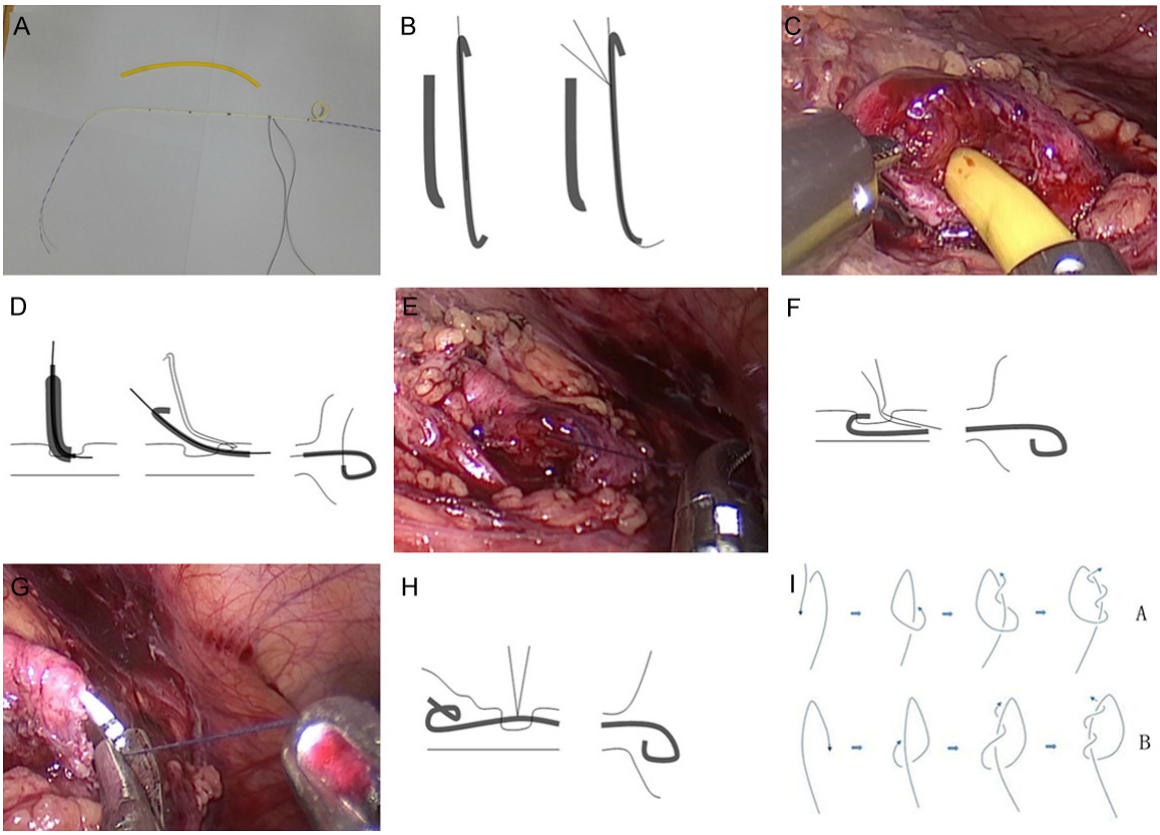

Figure 2. Illustration of the improved method of D-J stent insertion and suture of incision. A. Preparation of D-J stent. B. Schematic diagram of D-J stent. C-H. Insertion of D-J stent and corresponding schematic diagrams of D-J stent insertion. I. Incision suture and corresponding schematic diagram.

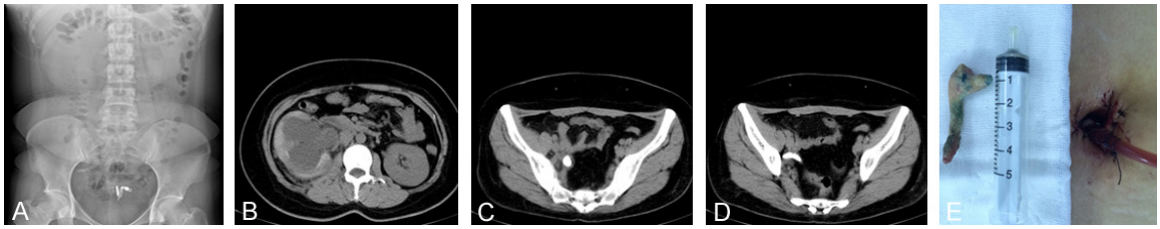

Figure 3. Diagnosis and treating outcome of Patients 1. A. Representative image of KUB. B. Hydronephrosis detected by CT scan. C and D. Location of stone detected by CT scan. E. Representative images of stone and incision suture.

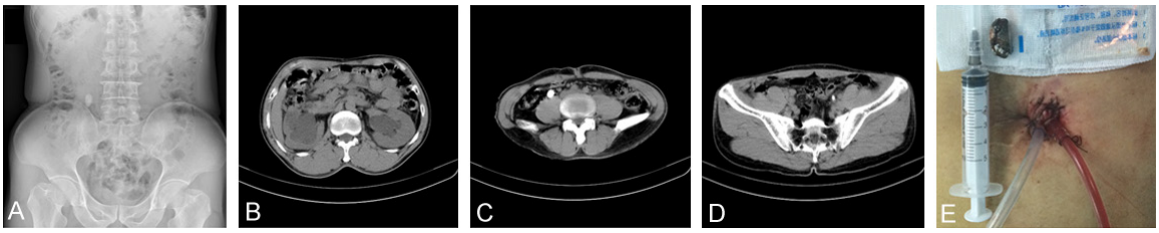

Figure 4. Diagnosis and treating outcome of Patients 2. A. Representative image of KUB. B. Hydronephrosis detected by CT scan. C and D. Locations of stones detected by CT scan. E. Representative images of stones and incision suture.

The stone removal rate, surgery duration, intraoperative blood loss, length of stay, and side effects of all the patients were recorded. Moreover, Vancouver scar scale (VSS) was employed for the assessment of scar recovery after ureterolithotomy or pyelolithotomy with LESS.

Results

Patient demographics

Ureterolithotomy with LESS or pyelolithotomy with LESS was successfully performed with all the patients (45 cases with 53 sides) and the success rate was 100% for the cohort. The average surgery duration was 97 (ranging from 70 to 115) min and the average intraoperative blood loss was 15 (ranging from 5 to 20) mL. Drainage tubes were maintained for two days and urinary catheters were maintained for 4 to 7 days. The patients stayed in hospital for 2 to 5 day and three cases (6.67%) received the painkiller treatment after the surgeries. One to two months after the surgeries, D-J stents were removed and patient conditions were examined with KUB and CT. The results showed that hydronephrosis was attenuated in all the patients and no ureterostenosis was recorded. The average VSS score of the incisions was 2.3 (ranging from 2 to 4), representing a good recovery of the scars. In the long-term follow-up (ranging from 3 to 12 months), no severe side effect was observed for any patients in the cohort.

Case reports

Case 1

A 26-year-old female was hospitalized for having pain and fever at right waist for seven days. Pain spot was located at the right kidney based on physical examination and fever was up to 39°C. Serum white blood cell level was 25.11 × 10^9/L and CT scan results showed that a cylindrical stone existed at the lower segment of the right ureter, together diagnosed as stone combined with infection. After ureterolithotomy with LESS, the patient's body temperature and blood parameters were restored to normal levels. After the removal of D-J stent, the results of KUB and CT demonstrated no stone left in the ureter. In the long-term follow-up, the patient was satisfactory with the cosmesis and no severe side effect or reoccurrence was recorded (**Figure 3**).

Case 2

A 51-year-old male was admitted for having a left-waist-pain history for ten years and the pain had been deteriorating since the last month. Based on the physical examination, the pain was located at the left kidney and the CT scan results showed that there were hydronephrosis in both kidneys and stones in bilateral ureters. The diameters for the stones were 3 cm for the left and 1.5 cm for the right. Given the fact that the patient received gastric perforation neoplasty before, the clinician decided to perform ureterolithotomy with LESS at both sides for the treatment, and the surgery successfully eliminated the stone. After the removal of D-J stent, the examinations with KUB and CT indicated a stone-free condition of the ureter. In the long-term follow-up, the patient was satisfactory with the cosmesis and no severe side effect or reoccurrence was recorded (**Figure 4**).

Discussion

ESWL is the technique removing stones by subjecting ureters to shock wave administration. However, for some USD patients, the chronic incarceration of stones in ureters can lead to the formation of ureteral polyp and further impair the stone removing capability of ESWL [4]. URS is the technique operated through urethras and ureters and it is also proved that patients receiving URS have rapid recovery rates [16]. Compared with URS and ESWL, PCNL is more efficient to remove stones but will result in hemorrhea or urinogenic sepsis. Given the fact that non-invasive surgery methods are not suitable for all the USD patients, treatments with LESS-based surgeries is a currently more effective strategy [17]. Ureterolithotomy or pyelolithotomy with LESS is characterized by low incidence of infection, hemorrhea, and post-surgery ureterostenosis. The theoretical stone removing rate can be as high as 100%. More importantly, surgeries based on LESS have a significant improvement on cosmesis, which is a central concern on invasive surgeries by patients [18].

In the current study, incisions were made in a "U" shape at ruga around umbilical. Outer wall of umbilical tube is a structure containing few

vessels and nerves, therefore, the introduction of instruments through the area will benefit patients by causing less blood loss and nerve damages as well as less scars [19]. The theory was verified based on our investigation: the average VSS score of the incisions was 2.3, which represented a scar-free outcome of the surgery. Six of 45 cases in the current were diagnosed to have stones in ureter at both sides. By employing traditional laparoscopic surgeries or open surgeries without LESS, six incisions will be needed. However, with ureterolithotomy or pyelolithotomy using LESS, only one small incision was made at ruga around umbilical for each patient. Due to the satisfactory cosmetic effect, LESS has little negative effect on the psychological states of patients and is especially welcomed by youthful and middle-aged females.

As early as 2008, LESS had been employed to facilitate the operation of ureterolithotomy by Rane et al. [20]. However, the promotion of LESS was limited in the following few years. The major factor restricting the application of LESS was the complicated operation skills which depended on a long-term study to handle [21]. With the development of techniques such as reversible laparoscopy, 3D laparoscopy, and other assistive techniques, the operation of LESS had been gradually simplified [22]. Nevertheless, the introduction of assistive techniques dramatically increased the cost of LESS, which made the technique less friendly to salariat [23]. In 2012, Wen et al. used a homemade two-port device to fulfill the operation of ureterolithotomy with LESS, which significantly cut down the cost of the surgery [24]. In the study of Cepedal et al. [15], the clinicians improved the device to single-port, further lightening the financial burden of the patients. The current study improved the device by cutting the length of trocar to 8 cm, which kept the device out of the abdominal cavity during surgeries and substantially reduced the need for operation skills. We also modified the inserting operation of D-J stent, which shortened the retention duration of D-J stent to 2 to 7 min, evidently saving the surgery time. Moreover, due to the limited space within the device, incision suture after surgeries with LESS was also difficult. Generally, the continuous suture of the incision can save surgery time but will itself lead to ureterostenosis [25]. To solve the problem, we modified the suture method based on the study of Choi [26], which further simplified the operation and improved the surgery outcome: the average surgery duration was 97 min and the average intraoperative blood loss was 15 mL for patients. For 10 patients impaired with pyonephrosis, no infection was observed after the surgeries, solidly supporting our conclusion that the improved LESS method employed in the current study was effective and safe. It was found that the most patients involved in the analysis were youthful and middle-aged females and had an average BMI of 22.4, also setting obstacles to the surgery. Additionally, some patients in the current study received intra-abdominal surgeries that resulted in omentum majus and intestine adhesion in abdominal cavity, which should be avoided if the outcomes of the surgeries need to be perfect.

In summary, for USD patients not available for treatments with URS or PCNL, surgeries with LESS will be a good option. With the improvements on the single-port device, D-J stent insertion, and incision suture, the patients in the current study showed considerable recovery and satisfactory cosmesis without severe side effects. The technique is especially suitable for females of youth and middle-age and has the value to be promoted in clinic. However, shortcomings existed for the current research: the assessment of the technique was only performed in one center. Therefore, to promote the application of surgeries with LESS, more clinical observations regarding the long-term outcomes of the technique will be conducted in multiple centers.

Disclosure of conflict of interest

None.

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