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Real-time simultaneous endoscopic combined intrarenal surgery with intermediate-supine position: Washout mechanism and transport technique

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Endoscopic combined intrarenal surgery (ECIRS) with simultaneous retrograde intrarenal surgery (RIRS) and percutaneous nephrolithotomy (PCNL) has been proposed as a new surgical treatment to overcome the disadvantage of RIRS and PCNL monotherapies in the treatment of renal stone. One of advantages of ECIRS is that it can increase stone-free rates in complex renal stone within single-session. Intermediate-supine position in real-time simultaneous ECIRS can prevent an anesthesiologic problem, and patient's burden is small even for long-term operation. Thus, we will share the experience and advantages of real-time simultaneous ECIRS and introduce techniques to increase the stone-free rate.

Keywords: Kidney; Nephrolithiasis; Ureteroscopy; Urinary calculi

INTRODUCTION

The first-line treatment of endourological interventions for renal stones is extracorporeal shock wave lithotripsy (ESWL), retrograde intrarenal surgery (RIRS) with flexible ureterorenoscope, and percutaneous nephrolithotomy (PCNL) [1]. Among these three interventional treatments, PCNL is currently the most effective treatment option for renal stone >2 cm [2]. In the European Association of Urology Urolithiasis Guidelines, ESWL and RIRS are recommended as first-line treatment for renal stone <2 cm in length, and PCNL is recommended as a first-line treatment for renal stone ≥2 cm [3]. However, PCNL monotherapy has limitations in the treatment of complex renal stone. Without hydronephrosis, a percutaneous approach may be difficult, and multiple tracts may be needed to access all calyces. In addition, stone fragments migrate to the ureter, and residual fragments are common. RIRS has made rapid progress since the 1990s when the holmium:yttrium aluminum garnet laser system was introduced [4]. Recently introduced small

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diameter digital videoscope and single-use videoscope has led to the popularization of RIRS by improving image quality and improving durability. However, there is a limit to achieving stone-free status for large renal stones ≥2 cm with single-session RIRS alone [2,5]. Therefore, endoscopic combined intrarenal surgery (ECIRS) with simultaneous RIRS and PCNL has been proposed as a new surgical treatment to overcome the disadvantage of RIRS and PCNL monotherapies in the treatment of renal stone [6-8]. One of advantages of ECIRS is that it can increase stone-free rates in complex renal stone within single-session [9]. We will share the experience of real-time simultaneous ECIRS and introduce techniques to increase the stone-free rate.

SURGICAL TECHNIQUE

1. Patients and results

We performed real-time simultaneous ECIRS on 30 adult patients in August 2017 to February 2018. The study was performed in accordance with all applicable laws and regulations, good clinical practices, and the ethical principles described in the Declaration of Helsinki. The Institutional Review Board of Severance Hospital approved this study protocol (approval number: 1-2017-0096). The study was exempt from requiring the participants' written informed consent because of its retrospective design and because the patients' records and information were anonymized and de-identified prior to analysis. Twenty-one patients were male and nine were female and mean age was 60.60±11.39 years. The main stone in the right side were 13 cases and left were 17 cases and 9 cases were bilateral renal stones. The location of the stone was midpole stone in 2, lower pole stone in 4, and mid to lower pole in 4. Multiple stones were observed in 17 cases and the Seoul National University Renal Stone Complexity (S-ReSC) score was 4.13±1.57 [10]. The average modified S-ReSC score was 6.10±2.48 [11]. Mean maximal stone length was 28.86±14.86 mm. The average mean stone density was 961.23±365.74 HU and mean stone heterogeneity index was 204.20±107.84 HU [12]. Nine patients underwent simultaneous ipsilateral ECIRS and contralateral RIRS, and four patient underwent ipsilateral ureteroscopic ureterolithotomy. Mean operative time was 89.23±36.14 minutes, and the patient was discharged on postoperative day 3.63±7.77. Stone-free rate was 80.00% and success rate with clinical insignificant residual fragments was 86.67% in all cases. In comparison between non-stone-free and stone-free patients, mean age, BMI, and MSL showed statistical significance (Table 1). All patients underwent retrograde loop-tail ureteral stent insertion (Polaris Loop; Boston Scientific, Marlborough, MA, USA) during ECIRS and no patients had nephrostomy.

2. Intermediate-supine position for real-time simultaneous endoscopic combined intrarenal surgery

Before ECIRS, the desired calyx was punctured under fluoroscopic guidance and a guidewire was inserted by an interventional radiologist. Then, an ECIRS was performed with the patient under general anesthesia in the intermediate-supine (Galdakao-modified supine Valdivia, GMSV) position. For intermediate-supine position, the patient was placed in the supine position with a 1-L saline bag below the ipsilateral flank. Thus, the ipsilateral flank was elevated 20 degree, causing the posterior calyx to project more laterally (Fig. 1) [13].

3. Retrograde approach

Using cystoscopy, a hydrophilic guidewire (Roadrunner

Table 1. Demographic data of total patients and comparison between non-stone-free and stone-free patients

Variable	Total	Non-stone-free patient	Stone-free patient	p-value
No. of patient	30	6	24	
Age (y)	60.60±11.39	51.50±6.89	62.88±11.24	0.026
BMI (kg/m^2)	24.63±2.14	27.68±0.78	23.86±1.62	<0.001
MSL (mm)	28.86±14.86	42.03±9.86	25.56±14.16	0.012
MSD (HU)	961.23±365.74	1,009.60±351.27	949.13±375.60	0.724
SHI (HU)	204.20±107.84	193.60±112.30	206.85±109.02	0.793
S-ReSC score	4.13±1.57	4.83±1.17	3.96±1.63	0.228
Modified S-ReSC score	6.10±2.48	6.83±2.64	5.92±2.47	0.428
Multiplicity	17	6	11	0.053

Values are presented as number only or mean±standard deviation.
BMI, body mass index; MSL, maximal stone length; MSD, mean stone density; HU, Hounsfield unit; SHI, stone heterogeneity index; S-ReSC, Seoul National University Renal Stone Complexity.

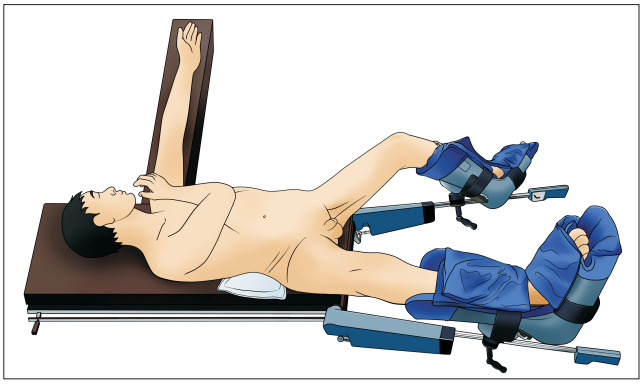

Fig. 1. The endoscopic combined intrarenal surgery was performed with the patient under general anesthesia in the intermediate-supine (Galdakao-modified supine Valdivia) position. The patient was placed in the supine position with a 1-L saline bag below the ipsilateral flank.

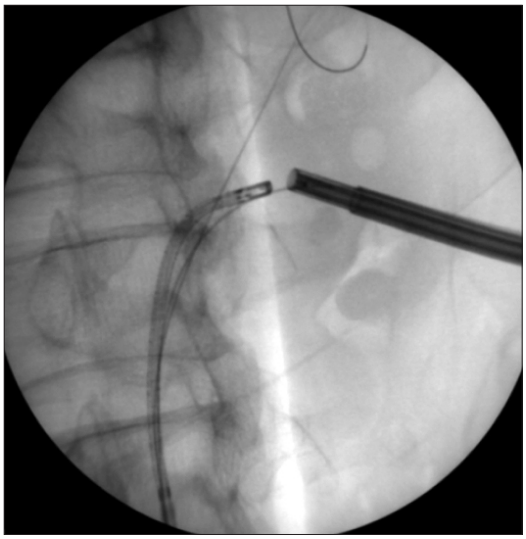

Fig. 2. During real-time simultaneous endoscopic combined intrarenal surgery, nephroscope and flexible ureterorenoscope can take finger-touch to see each other. The appearance of the two endoscopes facing each other is similar to the fingertip in the movie E.T., and we named it finger-touch.

Wire Guide; Cook Medical, Bloomington, IN, USA) was inserted into the ureter. A dual-lumen catheter was inserted through the hydrophilic guidewire, and retrograde pyelography was performed. Through the second lumen of dual-lumen catheter Amplatz Superstiff Guidewire (Boston Scientific) was inserted.

4. Antegrade approach

Using preoperative nephrostomy tract, a hydrophilic guidewire was inserted into the renal pelvis and ureter. The tip of guidewire was rolled within the bladder. Retrograde 11/13 ureteral access sheath (UroPass; Olympus, Tokyo, Japan) was inserted through the Amplatz Superstiff Guidewire. After installation of ureteral access sheath, there were two safety hydrophilic guidewires which were from nephrostomy and urethra outside ureteral access sheath. Using dual-lumen catheter, the second antegrade guidewire (Amplatz Superstiff Guidewire) was inserted to tract dilatation. Under flexible ureterorenoscopic guidance, the tract was dilated with an 18-Fr Ultraxx Nephrostomy Balloon (Cook Medical), or metallic one-step dilator, or 24-Fr NephroMax High Pressure Nephrostomy Balloon Catheter (Boston Scientific). The 20.8-Fr Universal Nephroscope (Richard Wolf, Knittlingen, Germany), 15-Fr (Richard Wolf), or 12-Fr miniature nephroscopes (Karl Storz Endoskope, Tuttlingen, Germany) were used (Video clip 1, Supplementary material).

5. Finger-touch of two endoscopes

In the intrarenal space, nephroscope and flexible ureterorenoscope can take finger-touch to see each other (Fig. 2). The appearance of the two endoscopes facing each other is similar to the fingertip in the movie E.T., and we named it finger-touch. The intrarenal space in which the finger-touch is performed is designated as the finger-touch space. Using flexible ureterorenscope, upper calyceal stones and the difficult access area using nephroscope should be examined. Using nephroscope and Amplantz sheath, mainly stone was fragmented by LithoClast Master (EMS, Nyon, Switzerland), ShockPulse (Olympus) in cases using Universal Nephroscope or Holmium laser (mini-nephroscope) in cases using miniature nephroscope and extracted by stone forceps. During ECIRS, stone dusting was performed using Holmium laser 200 μm fiber for RIRS.

6. Passive retrieval using washout mechanism

With real-time ECIRS, when the nephroscope is removed from the Amplantz sheath, fragmented stones exit through the sheath (Video clip 2, Supplementary material). The reason for these passive retrievals is the intermediate-supine position, which is why the downward orientation of the Amplantz sheath is the first reason. In addition, through the flexible ureterorenoscope, the irrigation fluid is continuously discharged toward the stone, so the fragmented stone is naturally discharged through the Amplantz sheath (Fig. 3). This principle is called the washout mechanism which increases the passive retrieval rate of real-time ECIRS.

7. Transport technique

In PCNL monotherapy, fragmented stones are transferred to another calyx. In PCNL monotherapy, the Amplantz sheath is allowed to enter the nephroscope by increasing the maximum angle. In this case, renal

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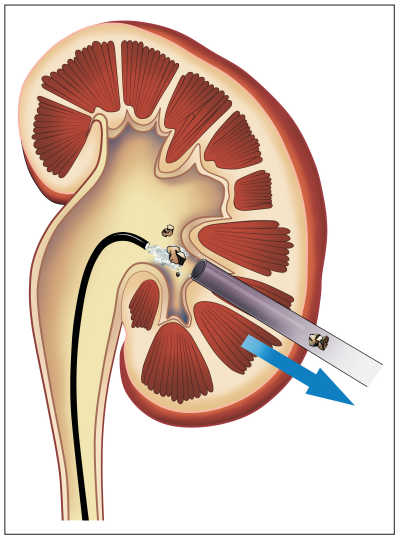

Fig. 3. With real-time simultaneous endoscopic combined intrarenal surgery, when the nephroscope is removed from the Amplantz sheath, fragmented stones exit through the sheath (arrow direction).

parenchymal injury may cause bleeding. When, another stones were located in the upper pole, the upper pole approach is additionally performed and multi-tract PCNL is performed, if the lower pole approach could not be accessible to upper pole stones. However, in real-time simultaneous ECIRS, when approaching the upper pole after the entrance of the Amplantz sheath with the lower pole is not easy, we can use a flexible ureteroroscope and stone basket to grasp the stone located at the upper pole. By moving the grasped stone to the finger-touch space, the nephroscope can identify the stone grasped in the basket, and the nephroscopic stone forceps can be used to remove the stones in the basket through the Amplantz sheath. This method of removing stones is named as the transport technique of real-time simultaneous ECIRS (Video clip 3, Supplementary material).

DISCUSSION

Scoffone et al. [8] first started using the name ECIRS and reported their postoperative outcomes. In their study of 127 patients, ECIRS was reported as a safe and effective technique, but popularization of these surgeries was accompanied by the development of a flexible ureteroscope [14,15]. ECIRS is a synergic approach combining RIRS and PCNL, and has both the advantages of PCNL and RIRS [16]. This new stone surgery is free of antero-retrograde approach, so ureter and renal stone can be treated at once. In addition, real-time simultaneous ECIRS has the advantage of safely and effectively performing a nephrostomy tract approach. We will summarize the advantages and limitations of our real-time ECIRS in this discussion.

1. Advantage

The main advantage of the intermediate-supine (GMSV) position is the reduction of the anesthesiologic problem. Cardiovascular and respiratory problems may be common in obese or old patients when performed with a prone position [17]. Intermediate-supine position can prevent an anesthesiologic problem, and patient's burden is small even for long-term operation. Another advantage of intermediate-supine position is the increased passive retrieval rate with the washout mechanism. Even in supine PCNL, stone fragments tend to be more excreted by grafting than the prone PCNL in Amplantz sheath. However, during real-time simultaneous ECIRS, irrigation fluid with pressure from the flexible ureterorenoscope is discharged to the renal pelvis, which is more favorable for discharging stone fragments and increasing passive retrieval than prone PCNL. Especially, it can be an effective method to increase the passive retrieval rate while lowering intrarenal pressure through access sheath and nephrostomy Amplantz sheath.

Percutaneous renal access under flexible ureterorenoscopic vision can also be safely and effectively performed without renal parenchymal injuries. Percutaneous access to the collecting system is a factor that can increase the stone-free rate of PCNL [18]. In addition, the advantage of real-time flexible ureterorenoscopy is that the anatomical structure can be understood in a complex way through two video systems. Even when multi-tract PCNL is needed, the number of tracts can be reduced because of simultaneous RIRS, and it is also safe to remove the renal stone with anatomical difficulty [19,20]. As the number of nephrostomy tracts increases, renal parenchymal loss and bleeding may be developed [21]. It may also be advantageous to reduce nephron loss because the PCNL tract itself causes renal parenchymal damage [22]. Through the transport technique suggested by us, the stone located in the upper calyx can be removed without additional tract. This technique can increase the stone-free rate because removal is possible for small or fragmented stones in the upper pole. The advantage of ECIRS is that even in patients with ureter stone and renal stone, surgery is possible without changing the position. Manikandan et al. [23] performed ECIRS on simultaneous renal and ureter stones in 43 patients. The authors concluded that ECIRS is a novel and excellent procedure in patients with simultaneous renal and ureteral stones, which can increase the stone-free rate and lower morbidity than conventional prone PCNL. Kwon et al. [24] performed single-session ECIRS, performed ECIRS

for ipsilateral large renal stone, and performed RIRS for treatment of contralateral renal stone. The authors analyzed the results in 26 patients and reported that the stone-free rate of ECIRS was 76.9% (20/26) and the contralateral RIRS was 92.3% (24/26). In this way, ECIRS and contralateral RIRS can be performed at the same time, so that single-session treatments for multiple stones are possible. The advantage of our real-time simultaneous ECIRS is the same, and the advantage of surgeon is that X-ray exposure is reduced. Fluoroscopic examination can be reduced because it can estimate 3-dimensional images [16].

2. Limitation

The biggest disadvantage of real-time simultaneous ECIRS is the need for two endovision systems and the cooperation of two surgeons. Space is also required in the operating room where the two endovision systems will be located. In our serices we used a digital flexible ureteroscope. In the absence of a flexible ureteroscope, real-time ECIRS may be difficult to perform. Two separate assistants are needed and the physical loading of the circulating nurse is also increased. Also, cost problems can be a limitation of real-time ECIRS. In South Korea, there is a major disadvantage that the same renal stone treatment in unilateral cases can not require the cost of PCNL and RIRS at the same time. Therefore, as the number of cases of ECIRS increases, there is a possibility that the operation cost problem will become a burden in the hospital. There are also problems caused by the intermediate supine position. That problem is that it is difficult to make a PCNL tract. Kidneys are more mobile in the supine position and renal cavity is not well distended [25]. And tract length may be longer, which limits the movement of the nephroscope and may cause renal parenchymal damage [26].

3. Comments

For the past 20 years, PCNL has evolved steadily, and its pace of development has been very rapid, with the development of instruments such as mini-PCNL and the introduction of supine PCNL and tubeless techniques. Mini-PCNL has reached the level of Ultra-Mini-PCNL through Karl Storz's MIP system. Supine PCNL is no longer a surgery for unfamiliar position, and has become one of the options to choose depending on the condition of the patient and the state of anesthesia. The tubeless technique also has reached the level of total tubeless, because it is more favorable to control bleeding after surgery through radiologic interventional approach rather than nephrostomy. In addition, the digital image of full HD (1,080 pixel) and the introduction of PACS showed image quality that was unimaginable in the past. In addition, the introduction of the digital flexible ureteroscope has revolutionized the RIRS. The RIRS can be performed with a high quality image and a smaller diameter, and since the videoscope is not heavy, it has benefited from long-time operation. ECIRS has entered a period of popularization due to the development of PCNL and RIRS. The advantage of ECIRS is that it can increase the stone-free rate in high stone burden cases while minimizing renal parenchymal loss using a single tract. This is evidence that stone-free results can be obtained even in patients with high nephrolithometry scores. As a result, in the future, ECIRS will become a safe and stone-free stone surgery in complex renal stones.

CONCLUSIONS

Real-time simultaneous ECIRS is an operation that can form a PCNL tract very safely and increase the stone-free rate. The disadvantage that two endovision and two surgeons are still needed is a challenge to be overcome in the future.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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SUPPLEMENTARY MATERIALS

Accompanying videos can be found in the 'Urology in Motion' section of the journal homepage (http://www.icurology.org). The supplementary video clips can also be accessed by scanning a QR code, or be available on YouTube: video clip 1, https://youtu.be/1WKwCrrSPJQ; video clip 2, https://youtu.be/KeXcdvbplmo; video clip 3, https://youtu.be/zqTQ4m-0ISA.

Video 1. Under flexible ureteroscope, percutaneous approach was performed using 15/16 Fr miniature metallic sheath and miniature nephroscope.

Video 2. With real-time ECIRS, when the miniature nephroscope is removed from the Amplantz sheath, fragmented stones exit through the sheath.

Video 3. The transport technique of real-time

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simultaneous ECIRS. By moving the grasped stone to the finger-touch space, the nephroscope can identify the stone grasped in the basket, and the nephroscopic stone forceps can be used to remove the stones in the basket through the Amplantz sheath.

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