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Laparoendoscopic single-site nephrectomy with the aid of intraabdominal retractors

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Abstract

Objectives To evaluate the feasibility and clinical efficacy of a novel intraabdominal retractor device in laparoendoscopic single-site nephrectomy(LESS-N).

Methods Between February 2012 and February 2017, 98 patients underwent LESS-N in our institution, including 38 patients with benign renal disease and 60 patients with malignant renal disease. 39 were performed conventional LESS-N(C-LESS-N) and 59 were performed intraabdominal retractor-assisted LESS-N(IAR-LESS-N). Demographic data, and perioperative and postoperative data were collected and analyzed retrospectively.

Results All the procedures were completed successfully. In C-LESS-N group, four patients were added one 5-mm additional trocar and two patients were converted to open surgery. In IAR-LESS-N group, no patients required additional trocars or conversion to open surgery. The mean operative time was lower in IAR-LESS-N group than that in C-LESS-N group (94.2 min vs 127.4 min, $P < 0.05$). The mean renal vascular management time declined from 25.4 min in C-LESS-N group to 18.4 min in IAR-LESS-N group ($P < 0.05$). The mean estimated blood loss was 128.6 ml in C-LESS-N group and 102.3 ml in IAR-LESS-N group ($P < 0.05$). Two patients in C-LESS-N group required blood transfusion, while none of the patients in IAR-LESS-N group did. No severe postoperative complications occurred in both groups. Study limitations included retrospective study, short follow-up, and accumulated surgical experience and skills.

Conclusions Intraabdominal retractors allow performance of LESS-N with improved working space, quicker renal hilar management, and shortened total operative time. It is expected that the application of intraabdominal retractors, along with the new robotic platform might revive LESS and translate into a renewed future interest of LESS.

Keywords Laparoendoscopic single-site surgery · Nephrectomy · Intraabdominal retractor

Introduction

Laparoendoscopic single-site surgery (LESS) has been developed to offer a less morbid procedure with a better cosmetic outcome compared to conventional laparoscopic surgery [1, 2]. Early reports have demonstrated the feasibility and safety of a broad range of LESS urologic procedures, especially upper-tract LESS procedures [3–5]. LESS, however, was often difficult to fully expose the surgical area because of limited space for manipulating instruments and a lack of triangulation, so that the operation was laborious and the operative time was prolonged. To overcome these difficulties, extra surgical ports or needlescopic instruments, along with specialized curved instruments or robotic systems were proposed [6, 7]. These modifications offered better results in terms of surgeon's performance and convenience.

In our center, a series of intraabdominal retractors were recently introduced in LESS upper urinary tract surgery, aimed at improving the exposure of the surgical area and facilitating surgeon's performance. Here, we presented our initial experience of intraabdominal retractor-assisted LESS-nephrectomy (IAR-LESS-N) and focused on the comparison with conventional LESS-N (C-LESS-N).

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Methods

Patients

Between February 2012 and February 2017, 98 adult patients underwent LESS-N (60 radical nephrectomy for malignant neoplasms and 38 simple nephrectomies for non-neoplastic aetiology) by a single surgeon via either C-LESS-N or IAR-LESS-N in our center. Indications for simple nephrectomy included symptomatic poorly functioning small or hydronephrotic kidneys and a diuretic renogram confirming < 10% function in the target kidney with a normal contralateral kidney. Radical nephrectomy was performed for cases with a clinically confirmed T2 or lower tumor stage for which nephron-sparing surgery by either an open or laparoscopic approach was not possible. If a patient's overall condition was suitable for laparoscopy, we performed LESS, irrespective of the patient's body mass index (BMI) or previous operation history. Preoperative data were collected prospectively into our institutional review board-approved database that included demographic data, patient age, body mass index (BMI), and tumor characteristics. The ethics committee of Jiangsu Provincial Hospital of Traditional Chinese Medicine approved this study and informed consent was obtained from all patients.

Surgical technique

Under general anesthesia and endotracheal intubation, the patients were placed in a 45° flank position and supported by adequate padding (Fig. 1a, b). A ~ 3-cm long transumbilical incision was made to place a single-incision

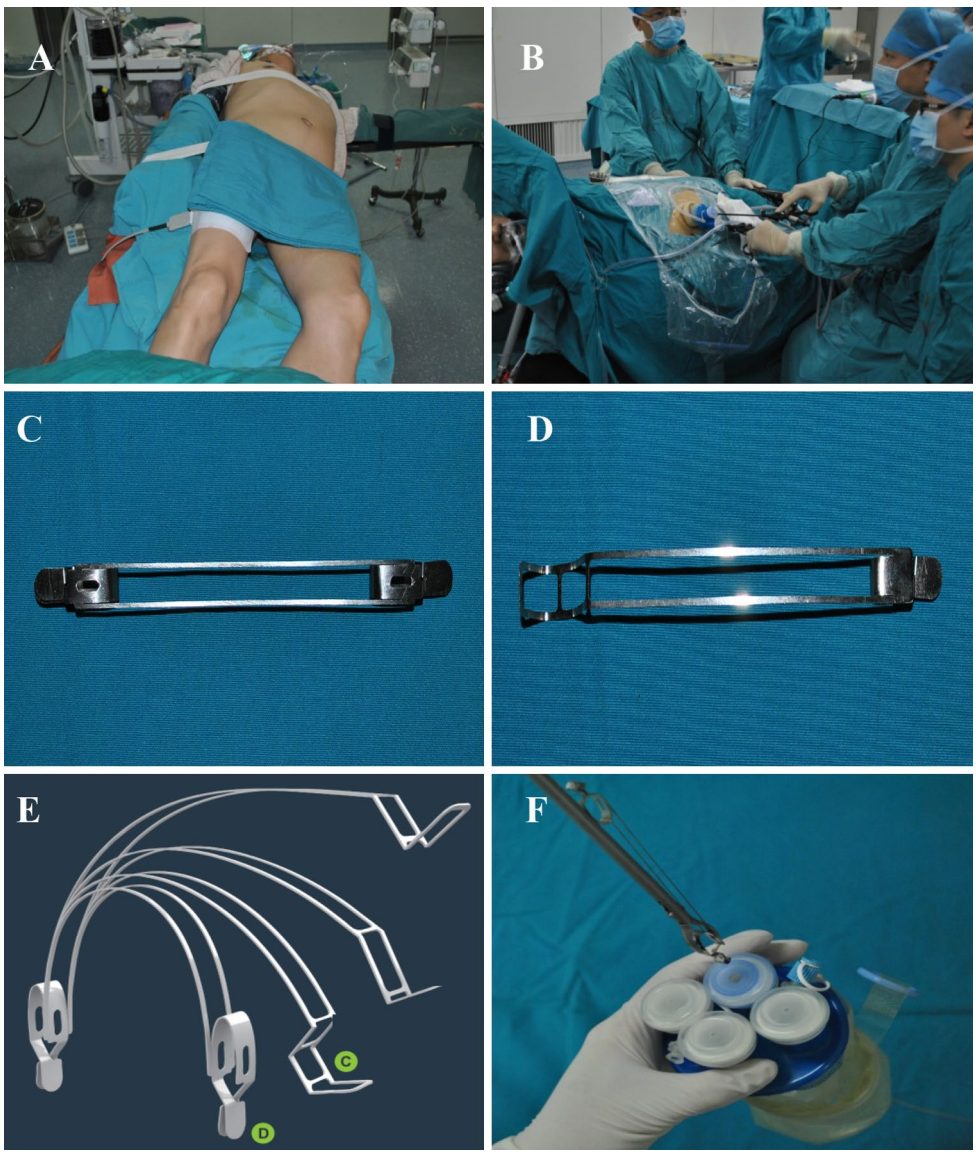

Fig. 1 Surgical position and tools for LESS-N (**a** Surgical position for patients performed LESS-N; **b** the surgeon sat on one side of the operating table for an operation; **c** type I intraabdominal retractors; **d** type II intraabdominal retractors; **e** diagrammatic representation of the use of intraabdominal retractors; **f** The retractor was held by a forceps and was inserted into the abdominal cavity through a 12-mm port)

multiport laparoscopic surgery trocar (Innovex Biosciences, Shanghai, China). The trocar contains one 12-mm and three 5-mm ports. Conventional straight laparoscopic instruments, such as dissectors, monopolar hooks, and needle holders, were routinely used. An all-in-one 5-mm 30° rigid laparoscope (Olympus Corporation, Tokyo, Japan) and a prolonged Sonicision™ 48-cm cordless ultrasonic dissection device (Covidien Medtronic, Minneapolis, MN, USA) were adopted in our LESS surgeries to reduce instrument interference. No articulating or bent laparoscopic instruments were needed.

After entering the abdominal cavity, dorsal peritoneum was incised laterally to the colon. Gerota's fascia was opened longitudinally and medially to the kidney. The ureter was identified, and dissection was continued proximally, toward the renal hilum. If severe hydronephrosis was present, the collecting system was drained through a small incision with an aspirator to achieve better exposure of the renal hilum.

For the cases in the C-LESS-N group, the renal artery and vein were fully dissected and double-clipped separately with 12-mm Hem-o-Lok clips. In most cases, the renal artery was located behind the renal vein and the artery should be carefully separated from the renal vein.

For another group of patients, a series of intraabdominal retractors (Ufremed Medical, Jiangsu, China) were inserted into the abdominal cavity through a 12-mm laparoscopic port and helped expose the surgical area. Intraabdominal retractors mainly had two types. Type I was characterized by toothless clamps at both ends, connected by two parallel wires with moderate toughness (Fig. 1c). Type II was distinguished by a toothless clamp at one end and a curved wire at the other end (Fig. 1d, e). After adequate dissection of the operative field, one end of the retractor was held by a forceps and inserted into the abdominal cavity through a 12-mm port (Fig. 1f). The toothless clamp was applied to tissues around the operative field that was to be retracted. The other end of the retractor clipped the contralateral tissue (Fig. 2a, b). The wires in the center were bent into an arch toward the abdomen. If optimal retraction was not achieved during the operation, readjustment was achieved by simply moving one end of the retractor. With this method, the overlaying loops of bowel or tissues above the kidney were easily retracted. When isolating the renal artery and vein, type II intraabdominal retractors could directly raise the renal vein with the curved wire at one end, exposing the renal artery clearly (Fig. 2c–f). After exposure, the renal vessels were ligated and severed. At the conclusion of the operation, the retractions were removed in the reverse order via trocar to avoid unintended injury.

For simple nephrectomy, the specimen was removed intact through the initial skin incision without the laparoscopic retrieval bag. For radical nephrectomy, the initial skin incision was extended in the cranio-caudal direction until the specimen in the laparoscopic retrieval bag could be extracted intact without severe resistance (Fig. 3a, b).

Statistical analysis

Surgery data including operative time, renal vascular management time, estimated blood loss, additional ports or conversion to standard laparoscopy, length of hospitalization, and any intraoperative and postoperative complications were recorded. Operative time was calculated from the time of skin incision to skin closure. Renal vascular management time was calculated from the time of isolating renal vascular to severing renal vascular. Statistical analysis was performed using SPSS version 22.0. Discrete variables were compared by x^2 analysis. Differences between groups were analyzed with Student's t test. $P < 0.05$ was considered statistically significant.

Results

Patient demographics

Table 1 lists the patients' demographics and tumor characteristics of the whole study cohort and the comparison between the C-LESS-N and IAR-LESS-N groups. 39 patients underwent C-LESS-N and 59 patients underwent IAR-LESS-N. Twenty-one patients had prior abdominal surgeries and LESS was successfully performed after adhesions were fully released. There were no significant differences in patients' demographics and tumor characteristics between two groups. Most patients had stage T1b tumors. One patient had stage T1a tumor; however, the tumor was near renal hilum and not suitable for nephron-sparing surgery.

Perioperative values and complications

In all cases, a transperineal access was adopted. Operative time, perioperative blood loss, and related variables are described in Table 2. In the C-LESS-N group, four patients were added one 5-mm additional trocar, and two patients were converted to open surgery because of vessel injury. In the IAR-LESS-N group, adequate retraction was achieved in all cases. Intraabdominal retractors maintained a consistent operative field and could be readjusted easily. There were no complications associated with intraabdominal retractors placement or removal. No patients required additional trocars or conversion to open surgery. The mean operative time was lower in the IAR-LESS-N group than that in the C-LESS-N group (94.2 min vs 127.4 min, $P < 0.05$). The mean renal vascular management time declined from 25.4 min in the C-LESS-N group to 18.4 min in the IAR-LESS-N group ($P < 0.05$). The mean estimated blood loss

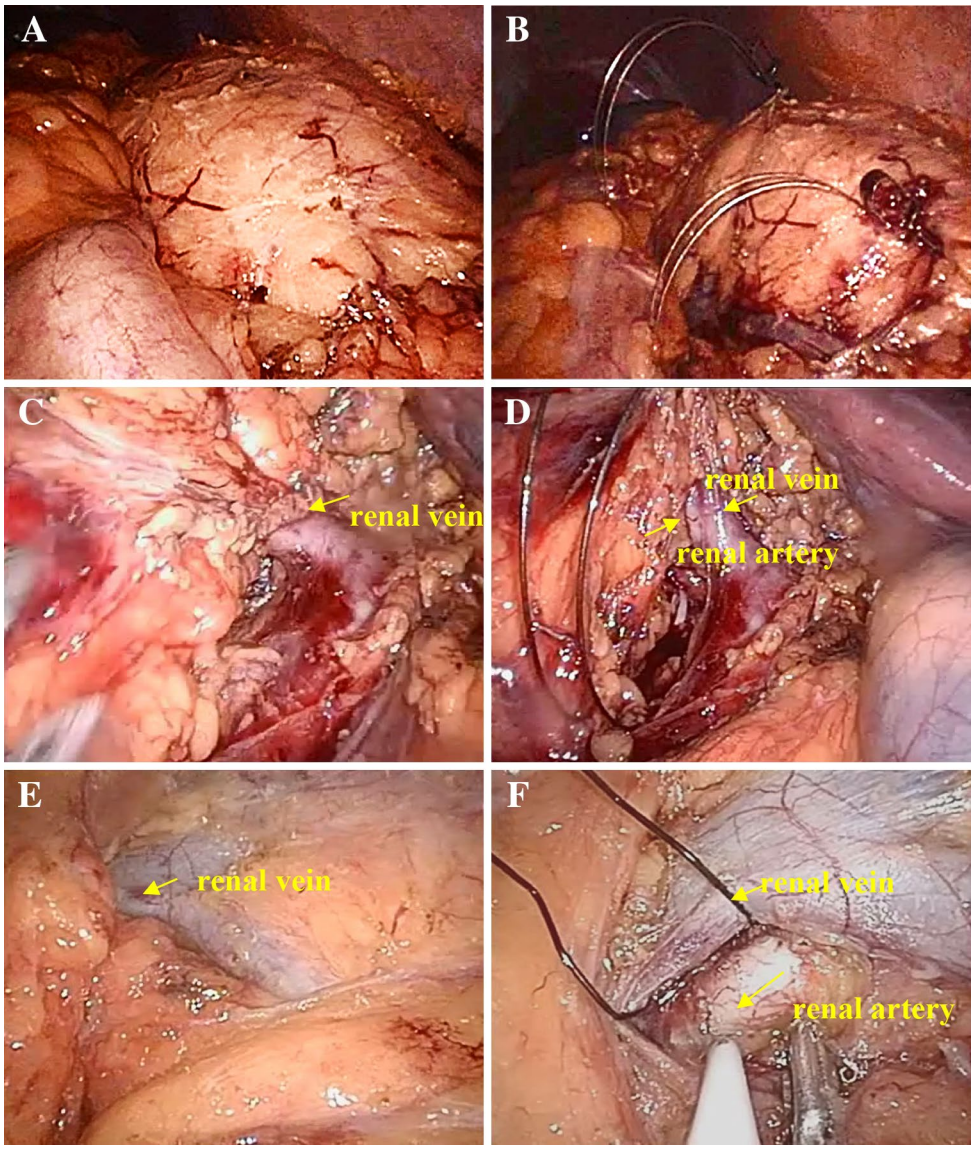

Fig. 2 Application of intraabdominal retractors in LESS-N (**a, c, e**, the structures of renal hilum were shown before the use of intraabdominal retractors; **b, d, f**, the renal hilum and renal artery were revealed by using intraabdominal retractors)

was 128.6 ml in the C-LESS-N group and 102.3 ml in the IAR-LESS-N group ($P < 0.05$). Two patients in the C-LESS-N group required blood transfusion, while no patients required in the IAR-LESS-N group. No severe postoperative complications occurred in both groups.

Pathology and follow-up

As shown in Table 1, there were 38 patients performed simple LESS-N because of benign indications, and the specimens had pathologies consistent with benign processes such as chronic pyelonephritis without evidence of malignancy. The remaining 60 cases were performed LESS radical nephrectomy because of enhancing renal masses. The definitive pathologic results revealed a renal cell carcinoma in these specimens. Most tumors were T1b stage and there were no significant differences in the pathological characteristics between two groups. All tumors were organ confined with negative surgical margins (Table 3).

Incision was totally hidden within the umbilicus in all patients (Fig. 3c). Local recurrence developed in one patient in the C-LESS-N group at 41 mo and then retroperitoneal laparoendoscopic surgery was performed. No patients in either group who underwent nephrectomy for malignant suspicion exhibited distant metastases.

Discussion

In 2007, Rane et al. [8] reported the first case of LESS-N in the world. From then on, LESS developed rapidly and became a new minimally invasive technique in urology. To date, most of the experiences with LESS in urology were reported by surgeons [4, 5, 9, 10]. However, in the past few

Fig. 3 Specimen and surgical scar (**a** Specimen of hydronephrotic kidney; **b** Specimen of malignant kidney; **c** Postoperative appearance of surgical scar after LESS-N)

years, there has been a decreasing interest on LESS because of the significant challenges for surgeons [11]. Technical difficulties have left laparoscopic surgeons in search of new methods to ease this burden.

As previously confirmed by scholars, when laparoscopic nephrectomy was performed, transperitoneal access had advantages such as large working space, clear vision, and readily identifiable anatomical landmarks. All of these were beneficial to LESS-N. However, the transperitoneal approach also had perceived disadvantages. For example, access to the renal hilum required retraction of the overlaying loops of bowels above renal hilum, and renal artery was usually deep behind the renal vein and difficult to isolate [12]. Fan et al. [13] conducted a meta-analysis of a comparative study on transperitoneal nephrectomy and retroperitoneal laparoscopic radical nephrectomy. The results indicated that transperitoneal approach had a longer renal artery control and operating time than retroperitoneal approach. The complications, such as intraoperative vascular injury, conversion to open surgery, also increased in transperitoneal approach [14]. To reduce the difficulty of the surgery and its complications, surgeons had tried some methods, including increasing the additional ports or needlescopic instruments, magnetic use of an anchoring and guidance system [15], and elevating the ureter with thread introduced through abdominal wall [16]. In 2013, Zhang et al. [17] used pulling-up technique to suspend the lower pole or the middle part of the kidney. The hilar vessels were visualized by this maneuver.

In the present study, we designed a serial of intraabdominal retractors to help expose the intraoperative working space. The retractors do not result in skin wounds. The middle of the retractor was two parallel wires with moderate toughness that could provide enough traction power to allow maintaining a stable retraction during the entire procedure. When necessary, readjustment of the retractors was easy by moving the clip to destination. The application of one or two intraabdominal retractors could result in optimal retraction of the surgical field. Furthermore, one end of type II retractor was a blunt bending wire, which could pull the tissues or renal vein effectively and no secondary injuries occurred during the operation.

With the help of retractors, no cases required insertion of additional ports or conversions to open approaches. Meanwhile, the operative time and renal vascular management time were shortened because of good exposure in the IAR-LESS-N group, suggesting that the use of intraabdominal retractors had made the surgery more manageable.

As with all oncological surgeries, oncological outcomes after radical nephrectomy were of paramount importance. In the present study, we observed local recurrence in one patient in the C-LESS-N group and no positive surgical margins were observed in both groups. These results were seemed to be equivalent to the existing literature [18, 19]. The lower recurrence rate may be the result of a shorter follow-up time.

Table 1 Clinical characteristics of patients

	C-LESS-N $n = 39$	IAR-LESS-N $n = 59$	p
Simple nephrectomy			
Patients, *n*	17	21	
Age, year, mean (range)	55.0 (30–75)	53.1 (44–68)	0.36
Gender, *n* (%)			0.796
Male	8 (47.1)	9 (42.9)	
Female	9 (52.9)	12 (57.1)	
BMI, kg/m^2, mean (range)	23.9 (17.5–28.4)	24.2 (19.5–27.9)	0.24
Target kidney, *n* (%)			0.635
Left	11 (64.7)	12 (57.1)	
Right	6 (35.3)	9 (42.9)	
Radical nephrectomy			
Patients, *n*	22	38	
Age, year, mean (range)	54.9 (30–71)	60.7 (50–76)	0.47
Gender, *n* (%)			
Male	14 (63.6)	24 (63.2)	0.970
Female	8 (36.4)	14 (36.8)	
BMI, kg/m^2, mean (range)	24.4 (22.7–33.3)	25.6 (23.9–29.1)	0.38
Target kidney, *n* (%)			0.381
Left	9 (40.9)	20 (52.6)	
Right	13 (59.1)	18 (47.4)	
Tumor size, cm, mean (range)	5.7 (3.5–7.6)	5.3 (4.2–7.5)	0.42
Clinical T stage of tumor, *n* (%)			0.343
T1a	1 (4.5)	0 (0)	
T1b	19 (86.4)	36 (94.7)	
T2a	2 (9.1)	2 (5.3)	

C-LESS-N conventional laparoendoscopic single-site nephrectomy, *IAR-LESS-N* intraabdominal retractor-assisted laparoendoscopic single-site nephrectomy, *BMI* body mass index

Table 2 Perioperative and outcomes of patients performed LESS-N

Outcomes	C-LESS-N $n = 39$	IAR-LESS-N $n = 59$	p
ORT, min, mean (range)	127.4 (80–230)	94.2 (65–140)	0.044*
Renal vascular management time, min, mean (range)	25.4 (14–40)	18.4 (14–23)	0.001**
EBL, ml, mean (range)	128.6 (50–600)	102.3 (50–160)	0.029*
Blood transfusion, *n* (%)	2 (0)	0(0)	
LOS, *d*, mean(range)	9.1 (7–14)	9.6 (6–14)	0.62
Additional ports used	4	0	
Number converted to open	2	0	

C-LESS-N conventional laparoendoscopic single-site nephrectomy, *IAR-LESS-N* intraabdominal retractor-assisted laparoendoscopic single-site nephrectomy; *ORT* operative room time, *EBL* estimated blood loss, *LOS* length of stay

The present study had several limitations. First, it was a retrospective study and the patients were not randomized, though the baseline characteristics between the two surgical approaches were not significantly different. Second, we simultaneously observed simple and radical nephrectomy and this may disturb the results. Separated analysis is needed in further study. Finally, although the same surgeon performed two groups of surgeries, the application of intraabdominal retractors was later and we need to consider the influence of more experienced and skilled techniques on the results of this study. Despite these limitations, our report may be helpful for surgeons who are not familiar with LESS and use of this tool may help to expand the application of LESS.

In conclusion, using intraabdominal retractors in LESS-N is feasible with improved working space, quicker renal hilar management, and shortened total operative time. It is expected that the application of intraabdominal retractors, along with the new robotic platform designed for single-site use might revive LESS and translate into a renewed future interest of LESS.

Table 3 Pathology and tumor characteristics in patients performed for malignant indications

Characteristics	C-LESS-N	IAR-LESS-N	*p* value
Patients, no	22	38	
Pathologic subtype, *n* (%)			0.414
Clear cell carcinoma	20	36	
Papillary carcinoma	2	1	
Chromophobe carcinoma	0	1	
Tumor staging, *n* (%)			0.359
pT1a	1 (4.5)	0 (0)	
pT1b	18 (81.8)	34 (89.5)	
pT2a	2 (9.1)	1 (2.6)	
pT3a	1 (4.5)	3 (7.9)	
Tumor grade, *n* (%)			0.846
Well differentiated	13 (59.1)	23 (60.5)	
Moderately differentiated	7 (31.8)	13 (34.2)	
Poorly differentiated	2 (9.1)	2 (5.3)	
Positive surgical margin, *n* (%)	0 (0)	0 (0)	
Local recurrence, *n* (%)	1 (4.5)	0 (0)	
Distant metastases, *n* (%)	0 (0)	0 (0)	

C-LESS-N conventional laparoendoscopic single-site nephrectomy; *IAR-LESS-N* intraabdominal retractor-assisted laparoendoscopic single-site nephrectomy

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Compliance with ethical standards

Conflict of interest Author Deng Zhonglei has received the research grant from Jiangsu Provincial Hospital of Traditional Chinese Medicine. Authors Su Jian, Zhu Qingyi, Yuan Lin, Zhang Yang, Zhang Qingling, Wei Yunfei, and Shen Luming declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were inaccordance with the ethical standards of the ethics committee of Jiangsu ProvincialHospital of Traditional Chinese Medicine and with the 1964 Helsinki declaration andits later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in thestudy.

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