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Hybrid laparoendoscopic single-site surgery of upper urinary tract with the use of mini-laparoscopic instruments: cosmetic outcome and midterm oncological outcome

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Abstract

Purpose

To evaluate the efficacy of mini-laparoscopic instruments in combination with laparoendoscopic single-site surgery (LESS) instruments for the performance of oncological urological surgery.

Methods

Thirty-five patients underwent oncological hybrid LESS either mini-laparoscopic-assisted LESS partial nephrectomy (LESS-PN, *n* = 12) or mini-laparoscopic-assisted LESS radical nephrectomy (LESS-RN, *n* = 23). Perioperative data were prospectively collected. The patient and observer scar assessment scale (POSAS) was used for the evaluation of the cosmetic outcome.

Results

Mean tumor size treated by LESS-PNs was 28.8 (IQR 20.5–37.3) mm. Average operative time and blood loss were 123 (IQR 112.5–145) min and 158.3 (IQR 100–200) ml, respectively. Renal artery clamping took place in seven cases. LESS-RN was performed in cases with a mean tumor size of 60 (IQR 48–71.5) mm. The average operative time was 116.8 (IQR 100–130) min. Average blood loss was 137 (IQR 100–150) ml. Complications were limited to grade II according to Clavien classification. The oncological outcome, including midterm results, was directly comparable to the literature. Patients reported low pain scores and high satisfaction in terms of postoperative scarring. The POSAS scores confirmed the excellent cosmetic outcome of hybrid LESS.

Conclusion

The combination of mini-laparoscopic and LESS instrumentation as routine equipment of oncological surgery provided an efficient option for urologic surgery. The combination of mini-laparoscopic and LESS instruments improves the intraoperative ergonomics of LESS-PN and LESS-RN. The provided surgical and oncological outcome compares favorably to the LESS and conventional laparoscopic literature.

Keywords

LaparoendoscopicSingle-siteNeedlescopicNephrectomyScarlessMini-laparoscopic

Introduction

The concept of "scarless" laparoscopic surgery has greatly evolved with the introduction of laparoendoscopic single-site surgery (LESS) and natural orifices transluminal endoscopic surgery. Both approaches aim into achieving an improved cosmetic result without compromising the overall surgical outcome. LESS achieved high standards of efficacy with the introduction of specially designed instruments and the constant development of technical refinements [1, 2]. Despite the aforementioned introduction of specially designed for LESS instruments, the technical difficulty remains high and the successful accomplishment of a LESS procedure may require the use of additional instruments inserted through the abdominal wall from sites other than the single port [2]. The use of 3 mm instruments should be considered as the most favorable option since these instruments require a very small incision which results in minimal scar formation [2, 3]. The authors have previously reported the routine use of 3 mm mini-laparoscopic instruments as a mean to overcome the ergonomic difficulties of LESS without compromising the cosmetic outcome [3].

In an attempt to further document the aforementioned concept for the practice of LESS, we retrospectively review the surgical outcome of upper urinary tract procedures performed in two tertiary institutions.

Patients and methods

LESS oncological surgery was performed in 35 patients in two institutions actively involved in LESS. The procedures took place between July 2009 and April 2014. Twelve patients underwent mini-laparoscopic-assisted (hybrid) LESS partial nephrectomy (LESS-PN) and 23 patients mini-laparoscopic-assisted (hybrid) LESS radical nephrectomy (LESS-RN).

Data collection and evaluation of the surgical outcome

Perioperative parameters for the above patients were prospectively recorded in the databases of the participating institutions, and the data were retrospectively extracted for the purpose of the study. Operative time was measured from initiation of the first incision to the closure of the last incision. Complications were classified according to the Clavien–Dindo system [4]. Hospitalization time included the day of admission, day of surgery, and postoperative hospitalization. The renal function was presented as estimated glomerular filtration rate (eGFR) and was calculated according to the modification of diet renal disease equation. The PADUA score was used for the evaluation of the characteristics of the renal tumors in cases performed after January 2010 [5].

Evaluation of postoperative pain took place in cases performed after January 2010 and included assessment on the day of surgery, first postoperative day, and at discharge. Pain was assessed by a visual analogue scale ranging from 1 to 10. Minimal pain was described as Score 1 and the worst possible pain as Score 10.

The cosmetic outcome of the procedures was routinely assessed in all cases of LESS-PN and the LESS-RN cases of one of the participating institutions performed after July 2011. The patient and observer scar assessment scale (POSAS) was used for the purpose [6]. The evaluation included a 5-point Likert scale which assessed the degree of patient satisfaction of their scars. The scale ranged between "Most satisfied" and "Least satisfied" and was based on previously described methodology [7]. The scale was administered by the attending physician to the patients at the first follow-up appointment scheduled at least 3 months after surgery.

Indications for surgery

LESS-PN and LESS-RN

The management of tumors was based on the EAU Guidelines [8]. Tumors up to 4 cm were treated by LESS-PN, while tumors up to 7 cm in diameter were also considered for LESS-PN whenever it was technically possible. Larger tumors were considered for LESS-PN for patients with imperative indication. LESS-RN was considered for all other cases of renal mass with suspicion of malignancy and lack of metastasis in the preoperative staging. The cases were performed in patients sensitive to the cosmetic outcome.

Surgical technique

Instruments

Endocone (Karl Storz, Tuttlingen, Germany) and Gelpoint (Applied Medical, Rancho Santa Margarita, CA, USA) were used based on the surgeon's preference and availability of the materials. A combination of curved and conventional laparoscopic instruments was inserted through the above ports. Mini-laparoscopic instruments (3 mm instruments/Karl Storz, Tuttlingen, Germany) with their respective trocars were placed through the abdominal wall. All instruments with diameters larger than 3 mm were inserted through the multi-port.

Initial steps

The multi-port was placed at the umbilicus or the lateral margin of the rectus muscle through a small incision depending on the preference of the surgeon and the patient habitus. A combination of 5 mm curved and straight instruments (5–12 mm in diameter) through the multi-port was used for the accomplishment of the procedure. The most cephaly placed mini-laparoscopic instrument was either inserted caudally to the xyphoid or on the midclavicular line. The caudally placed mini-laparoscopic instrument was positioned on the midaxillary line for tissue retraction. Two mini-laparoscopic instruments were placed in all cases.

The colon was mobilized at the line of Toldt. The Gerota's fascia was identified; the upper renal pole was mobilized from spleen or liver depending on the side of the procedure. A 3-mm instrument was sufficient for liver retraction in right-sided cases. The lower renal pole was also mobilized; the ureter was identified and prepared up to the renal hilum. The renal vessels were separately prepared.

LESS-RN

The renal vessels were separately ligated with Hem-o-lok clips (Teleflex Medical Europe Ltd, Dublin, Ireland) or were clipped en bloc with the use of EndoGIA vascular staplers-ECHELON Flex (Johnson and Johnson Medical GmbH, Norderstedt, Germany). The remaining attachment of kidney and the ureter were dissected. The resected kidney was placed in an endoscopic bag and removed through the multi-port incision (elongation if necessary).

LESS-PN

Renal vessels were clamped or not based on the decision of the surgeon. For small exophytic tumors, clampless technique was considered. Clamping took place with the use of Bulldog clamps (Aesculap AG, Mesulngen, Germany). Tumor excision was performed using ultrasonic scissors,

cold scissors, and bipolar coagulation. After the excision of the tumor, the renal lesion was reconstructed in two layers sliding clip renorrhaphy. Suturing took place with the combination of mini-laparoscopic and conventional instruments. The tumor was inserted in an endoscopic bag and removed through the multi-port incision.

A drain was left at the site surgery through either the site of the midclavicular or the midaxillary line port.

Postoperative management and follow-up

Drain was removed on the first or second postoperative day for LESS-PN and LESS-RN. The patients were followed according to the contemporary recommendations.

Data processing

Mean values and intraquartile range were calculated for the recorded parameters. Statistical analysis included the used of Student's *t* test, Mann–Whitney, or Wilcoxon test based on the available data. The IBM SPSS version 20 (IBM Corp., Armonk, NY, USA) was used for calculations and statistical analysis.

Results

All procedures were performed with a combination of mini-laparoscopic instruments with LESS instruments and materials. Table 1 shows the instruments used for each of the procedures evaluated in the current study. Obese and overweight patients were managed with access at the lateral margin of the rectus muscle. Conversion to conventional laparoscopy or open surgery was never deemed necessary.

Table 1

Instruments and materials used for the performance of LESS-PN and LESS-RN

Multi-port	**Partial nephrectomy (*n* = 12)**	**Radical nephrectomy (*n* = 23)**
Endocone	2	11
Gelpoint	10	12
Site of insertion		
Umbilical	10	22
Para-rectal	2	1
Vessel ligation		
Hem-o-lok	–	1
EndoGIA	–	10
Hem-o-lok + EndoGIA	–	10
Hem-o-lok + EndoGIA + tissue sealer	–	2
Vessel clamping	7	–
Hemostatics	12	14
Type		
None	–	4

Multi-port	Partial nephrectomy (*n* = 12)	Radical nephrectomy (*n* = 23)
Floseal	9	9
Tachosil	7	4
Tabotamp	–	3
Bipolar	12	11
Adjunctive instrument 1	12	23
Site of insertion: number of cases/purpose	Midclavicular line: 12/suturing, Tissue-liver retraction	Subxyphoid: 13/liver retraction Midclavicular line: 10/tissue retraction
Adjunctive instrument 2		
Site of insertion: number of cases/purpose	Midaxillary line: 12/suturing, Tissue retraction	Midaxillary line: 23/colon-kidney-tissue retraction

LESS-PNs (Table 2) were performed in 12 patients with a low PADUA score in six cases, intermediate in three, and high in another three cases. LESS-RN was performed in 23 patients. Perioperative results are presented in detail for both procedures in Table 2. Five cases of LESS-PN were performed with clampless technique. Complications were observed in two patients who developed fever postoperatively, and their hospitalization was extended. Positive surgical margins (PSMs) were observed in one case. Nevertheless, locoregional recurrence or metastasis was not observed in the cases that were assessed at the 24- and 48-month follow-up appointments. For LESS-RN, an overall complications rate of 13 % was noted and included only grade I complications. PSMs were not observed. Recurrence was documented in one case at the 48-month follow-up appointment and involved distant metastasis.

Table 2

Perioperative and follow-up data of partial and radical nephrectomy patients

	Partial nephrectomy	*p* value	Radical nephrectomy	*p* value
Perioperative parameters				
Number of cases/male/female	12/6/6		23/13/10	
Tumor side	Left: 3 Right: 9		Left: 10 Right: 13	
Mean age (IQR, years)	59.2 (53–68.2)		56.2 (44–67)	
Mean BMI (IQR, kg/m^2)	23.4 (21.9–25.1), 2 overweight[a] patients		25.4 (23.9–26.8) 9 overweight[a] patients/1 obese[b]	
Mean American Society of Anesthesiologists score (IQR)	2.2 (2–2)		2.4 (2–3)	
Charlson comorbidity index score (IQR)	2.12 (1–3)		1.87 (1–2)	
Average tumor diameter (IQR, mm)	28.8 (20.5–37.3)		64.7 (53–74)	
Venous invasion	–		6	
Pelvicalyceal involvement	–		17	

	Partial nephrectomy	*p* value	Radical nephrectomy	*p* value
PADUA score	Low (6–7): 6 Intermediate (8–9): 3 High ≥10: 3		High ≥10: 21	
Mean operative time (IQR, min)	123 (112.5–145)		116.8 (100–130)	
Mean estimated blood loss (IQR, ml)	158.3 (100–200)		137 (100–150)	
Clamping technique/mean warm ischemia time (IQR, min)	7/14.4 (10–18)		–	
Conversion to conventional laparoscopy/open surgery	0/0		0/0	
Mean incision length (IQR, mm)	34.6 (25–40)		60.2 (55–60)	
Mean hemoglobin drop (IQR, gr/dl)	1.16 (0.8–1.4)		1.14 (0.7–1.4)	
Mean creatinine increase (IQR, mg/dl)	0.11 (0.04–0.18)	0.25	0.25 (0.13–0.36)	<0.001
Mean eGFR decrease (IQR, ml/min)	12.7 (5–20)	0.25	27.7 (19–36)	<0.001
Mean hospitalization (range, days)	4.2 (4–4.75)		4.2 (3–5)	
*Complication*s				
Complication	Number of patients/Clavien grading/management			
Intraoperative				
Postoperative				
Fever	1/II/antibiotics		3/II/antibiotics	
Postoperative oncological evaluation				
Benign	–		1	
pT1a	10		–	
pT1b	2		9	
pT2a	–		2	
pT3a	–		11	
Positive surgical margins	1		0	
Positive lymph nodes cases	–		2	
Fuhrman grade	1: 6 2: 5 3: 1		1: – 2: 11 3: 10	

	Partial nephrectomy	*p* value	Radical nephrectomy	*p* value
Benign tumor histology	–		4: 1 Angiomyolipoma: 1	
RCC histology	Clear cell: 9 Papillary: 2 Chromophobe: 1		Clear cell: 20 Papillary: 1 Chromophobe: 1	
Mean follow-up (IQR, months)	37.5 (24–54)		22.3 (6–42)	
Follow-up 24 months				
Number of cases/recurrence	10/no recurrence		8/no recurrence	
Follow-up 48 months				
Number of cases/recurrence	5/no recurrence		5/1	
Recurrence site/management	–		Distant: 1/medical treatment	

Wilcoxon test was used for the statistical analysis

[a]BMI = 25–29.9

[b]BMI = 30 or greater

Pain assessment took place in all LESS-PN and ten LESS-RN cases. Pain was minimal postoperatively (Table 3). The POSAS revealed a high objective and patient-evaluated outcome with an average score below 14 in both procedures. Patients were highly satisfied with the scar appearance (Table 3).
Table 3

Average values of postoperative pain perception and results of the patient satisfaction in terms of postoperative scar appearance

Hybrid LESS	**Partial nephrectomy (*n* = 12)**	**Radical nephrectomy (*n* = 10)**
Average value of the pain score (IQR)		
On the day of operation	2.64 (2–3)	2.64 (2–3.25)
On the first postoperative day	2.01 (1–2)	2.14 (1–2)
Day of discharge	1.3 (1–1.25)	1.32 (1–1.25)
POSAS score and patient satisfaction in terms of postoperative scar appearance		
At the first follow-up appointment, at least 3 *months after surgery*		
Patients included in the evaluation	8	5
POSAS score		
Mean values (IQR)		
OSAS[a]	9.5 (8–11.5)	13.2 (11–16)
PSAS[b]	8.5 (6.2–9.7)	10.6 (9–12.5)

Hybrid LESS	Partial nephrectomy (*n* = 12)	Radical nephrectomy (*n* = 10)
Patient satisfaction		
Most satisfied	7	3
Somewhat satisfied	1	2
Neutral	0	0
Somewhat dissatisfied	0	0
Least dissatisfied	0	0

[a]The scale ranges between 5 and 50. Five represents “normal skin” and 50 the “worst” possible result

[b]The scale ranges between 6 and 60. Six represents “normal skin” and 60 the “worst” possible result

Discussion

The introduction of specialized instruments facilitated the performance of LESS procedures, but the technical difficulty remains high [1, 2, 9]. In reconstructive surgery, additional instruments played a more important role as the lack of triangulation rendered LESS into a task suited only for highly skilled laparoscopic surgeons [10]. The insertion of additional instruments in abdominal sites different than the multi-port has been proposed since the first steps of LESS [11]. Nonetheless, it could be advocated that the cosmetic outcome may be compromised due to the additional scarring related to the insertion of these instruments.

Mini-laparoscopic instruments have been used in other surgical specialties for almost two decades with high efficacy [12]. The pursuit for “scarless” surgery led some investigators to introduce the use of mini-laparoscopic instrument in conventional laparoscopy of the upper urinary tract [13]. The use of these instruments seemed to be favorable in terms of ease of use and cosmetic outcome [13, 14]. Current literature showed that there is an improved cosmetic outcome of mini-laparoscopic instruments in comparison with conventional laparoscopy without compromising the surgical outcome [14–16].

The authors favoured the idea on a combination of LESS with mini-laparoscopy. This concept aimed to combine the advantages of the minimal scarring and the triangulation of instruments provided by mini-laparoscopy with the concealed incision and the potential for the insertion of large diameter instruments provided by LESS instrumentation [3]. The mini-laparoscopic instruments allowed the performance of demanding reconstructive and oncological surgery requiring complex suturing tasks in a time-efficient manner without compromising the cosmetic outcome. The initial favorable experience was further developed to the clinical practice of the institutions.

LESS partial nephrectomy has been limited reported in the literature [3, 17–20]. Additional instruments have been used for the performance of LESS partial nephrectomy by several investigators. The current series compared at least favorably in terms of mean operative time, blood loss, and complication rate with a recent multi-institutional study presenting the experience on 190 LESS partial nephrectomies [21]. The results of the operative time, blood loss, and complication rates reported for conventional laparoscopic partial nephrectomy are similar to those of the current approach [22–24]. Moreover, the oncological outcome seemed to be similar among the two studies with very low percentages of PSMs and tumor recurrence. To our knowledge, the current series is the only study available to provide evidence on the midterm oncological outcome on a hybrid LESS approach for partial nephrectomy [25]. These results are directly comparable to conventional

laparoscopy results, and the current approach does not seem to be inferior to conventional laparoscopy [21–24, 26].

Renal function was reported to be compromised in long term when hilar clamping took place during laparoscopic partial nephrectomy [21]. The current study provided evidence showing that the renal function was not significantly compromised after LESS-PN ($p = 0.25$ for both creatinine and eGFR) and the above correlation could not be confirmed. The triangulation of the 3-mm instruments provided confidence to the surgeon similar to the laparoscopic approach to avoid hilar clamping and probably contributed to the acceptable warm ischemia time. Only cases of exophytic tumors were selected for the clampless approach, and the dissection was performed with a combination of ultrasonic scissors and bipolar coagulation.

In the current study, the 3-mm instruments were used on routine basis for the performance of LESS-RN. It could be advocated that the performance of LESS-RN is possible without the need of any additional instruments and these instruments could be avoided in order to avoid compromising the cosmetic outcome. Our previous experience revealed that the cosmetic outcome is not compromised by their use [3, 11]. The current study further documented the excellent cosmetic outcome. The patient satisfaction was high after both procedures. LESS-RN was related to marginally lower patient satisfaction as the specimen extraction required elongation of the incision. The evaluation of the cosmetic outcome represented one of the most interesting aspects of the current study as the literature includes limited evidence on the cosmetic outcome of LESS [2]. The use of POSAS is related to high efficacy in the evaluation of the postoperative scars and has the advantage of combining information from an objective evaluator and the patient [27].

The operative time, blood loss, complication rate, and oncological outcome of LESS, and the surgical and oncological outcome of LESS-RN are compared at least favorably to the current literature on LESS and laparoscopic radical nephrectomy [28, 29]. The midterm oncological outcome of LESS radical nephrectomy has not been adequately documented in the current literature, and the current series revealed similar results to conventional laparoscopy.

Limitation of the current study is the lack of a comparative group of laparoscopic cases. Such a comparison would require the use of retrospective data which may not provide adequate data on several parameters considered in the current study. The high patient satisfaction on the cosmetic outcome in the current population requires further confirmation in a prospective comparative study. The cosmetic outcome was not assessed by both institutions with the use of a validated method such as the POSAS. The estimation of the cost of the presented techniques was not a purpose of the current study. Due to the laparoscopic expertise of the centers involved, the results may not be reproducible in less experienced centers.

Conclusion

The combination of mini-laparoscopic and LESS instruments for LESS-PN and LESS-RN provided surgical outcome comparable to the LESS and conventional laparoscopic literature. Midterm oncological results were comparable to the laparoscopic literature. The cosmetic outcome resulted in high patient satisfaction due to the practically imperceptible scar of the 3-mm instruments. The above combination as routine equipment of oncological surgery provided an efficient option for urologic surgery with minimal scar formation.

Authors’ contributions

Kallidonis involved in protocol development, data collection, and data analysis, wrote, and edited the manuscript. Kyriazis involved in data collection and data analysis. Kamal involved in data collection and data analysis. Porpiglia involved in protocol development, data management, and data analysis, and edited the manuscript. Liatsikos involved in protocol development, data management, and data analysis, and edited the manuscript.

Compliance with ethical standards

Conflict of interest

No conflicts of interest are declared by the authors.

Ethical standards

All data were collected in databases approved by the participating institutions. Informed consent was obtained from all patients.

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