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Laparoendoscopic Single-site Partial Nephrectomy Without Ischemia for Very Small, Exophytic Renal Masses: Surgical Details and Functional Outcomes

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Abstract

Background: Laparoendoscopic single-site surgery (LESS) has emerged as a natural progression from standard laparoscopy aiming to further minimize the morbidity of urologic procedures.

Objective: To describe our technique and report the surgical and functional outcomes of unclamped LESS partial nephrectomy (PN) in the treatment of small renal masses (SRMs).

Design, setting, and participants: Prospective evaluation of pre- and postoperative variables of patients undergoing the LESS-PN without ischemia between 2009 and 2012. The indications were single exophytic SRMs.

Surgical procedure: Unclamped LESS-PN was performed through a transperitoneal approach. A pararectal Hasson access technique was preferred. Single-port access was achieved via different single-port devices. A combination of straight and articulating laparoscopic instruments was used. The tumor was excised using bipolar scissors during normal renal perfusion. Hemostasis was achieved by bipolar electrocautery, parenchymal stitches, and hemostatic agents.

Outcome measurements and statistical analysis: Demographic, operative, postoperative, and pathologic outcomes data were recorded and analyzed.

Results and limitations: A total of 21 LESS-PN were performed (operative time: 111 ± 41 min; blood loss: 196 ± 195 ml; tumor size: 2.0 ± 0.3 cm). Neither conversion to open surgery nor transfusions occurred. Three patients required conversion to standard laparoscopy. Postoperatively, three complications (Clavien grades 2, 3a, and 4) were recorded. Pathologic examination revealed 14 clear cell carcinomas, four renal cysts, two oncocytes, and one angiomyolipoma. Hospital stay was 4.4 ± 1.9 d. At the last follow-up (mean: 17 ± 11.5 mo), no port-site, local, or distant recurrences were detected. No significant variation in serum creatinine and estimated glomerular filtration rate was observed. Subjective scar evaluation indicated 66% of patients were very satisfied/enthusiastic. Study limitations include the small sample size, the lack of a control group, the short follow-up period, and the arbitrary measure of patient's scar perception.

Conclusions: Unclamped LESS-PN for selected SRMs is a safe and feasible procedure providing favorable postoperative outcomes and ensuring high levels of subjective, cosmetic satisfaction.

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1. Introduction

The incidence of small renal masses (SRMs) has increased significantly in the past three decades with the widespread use of imaging techniques [1,2]. Laparoscopic nephron-sparing surgery (NSS), combining preservation of renal function and minimal invasiveness, represents an alternative to open surgery [3]. Laparoendoscopic single-site surgery (LESS), an evolution of laparoscopic surgery, tries to overcome even the rare port-related complications of laparoscopy and seems to achieve a fast and painless postoperative recovery with excellent cosmetic results.

Our group pioneered the field of LESS partial nephrectomy (PN), and described the unclamped technique in 2009, achieving favorable early outcomes [4,5]. Since then, several series of LESS-PN have been reported and available evidence on this surgical procedure is now sufficiently large [6,7].

The aim of this study is to demonstrate the safety and feasibility of LESS-PN without hilar clamping by describing the technique and analyzing early oncologic and functional outcomes.

2. Patients and methods

Between April 2009 and March 2012, 21 patients were enrolled in this prospective study. The inclusion criteria were a single, exophytic, cortical, small (≤4.0 cm) renal mass suitable for standard laparoscopic PN without ischemia (Fig. 1).

Preoperatively, all the patients underwent ultrasound, computed tomography (CT) scan, or magnetic resonance imaging (MRI) with contrast medium, and all were informed that the minimally invasive procedure would be attempted via a single incision. Patients were also advised that additional incisions could be necessary as warranted during the surgical procedure. All relevant clinical information was introduced into an institutional database. The study protocol was approved by the internal review board.

The following data were collected: age, sex, body mass index, history and physical examination findings, specific comorbidities, American Society of Anesthesiologists class risk, operative time, tumor size, PADUA score [8], incision length, estimated blood loss (EBL), transfusion requirements, oral intake, and length of stay (LOS).

Pre- and postoperative hemoglobin, serum creatinine, and estimated glomerular filtration rate (eGFR) (estimated with the Modification of Diet in Renal Disease formula) [9] were recorded and analyzed by t test.

The visual analog scale score (VAS) (range: 1 [negligible pain] to 10 [severe discomfort/pain]) allowed for postoperative pain assessment (postoperative day [POD] 1). The cosmetic effect of the scar was reported at the first follow-up visit by the patients (arbitrary and subjective opinion: unsatisfied, satisfied, very satisfied, and enthusiastic).

Both medical and surgical complications were recorded according to the modified Dindo-Clavien classification [10]. Stage and grade tumor were assigned according to the 2002 TNM classification [11]. One laparoscopic surgeon (L.S.) performed all procedures. The follow-up was performed according to the proposed European Association of Urology algorithm [3]. Renal function was checked at every follow-up visit.

2.1. Surgical technique

2.1.1. Preoperative preparation and anesthesia

Low-molecular-weight heparin was administered subcutaneously the evening before the surgery and continued postoperatively once daily until day 21 for thromboprophylaxis. A single-shot intravenous antibiotic (cephalosporin, or other drug in case of allergy) was administered at the beginning of the anesthesia. The procedure was always performed under general anesthesia.

2.1.2. Patient positioning and instruments

The patient is placed in the 45–60° modified flank position and secured with the operating table minimally flexed. In the majority of cases, a pararectal transperitoneal approach was preferred following the Hasson technique. In these 21 patients, different, disposable, single-port devices (SILS Port [Covidien, Mansfield, MA, USA]; Triport and Quadport [Advanced Surgical Concepts, Bray, Ireland]; OCTO Port [Darim Corp., Seoul, Korea]; GelPOINT [Applied Medical, Rancho Santa Margarita, CA, USA]) and reusable trocars (Endocone, Karl Storz, Tuttingen, Germany) were used according to availability and the surgeon preference (Fig. 2). With a 12-mm Hg pneumoperitoneum and using a rigid 5- and 10-mm, 30° lens laparoscope (Karl Storz, Tuttingen, Germany), the peritoneal cavity is examined. A combination of standard and articulating instruments are used (Fig. 3).

2.1.3. Bowel reflection

The surgical strategy follows the conventional laparoscopic PN [12]. The colon and hepatic/spleen flexure are mobilized medially using a LigaSure (Covidien, Mansfield, MA, USA) 5-mm laparoscopic instrument (right hand) and straight grasper (left hand).

2.1.4. Ureteral identification and hilar exposure

The ureter with surrounding fibro-fatty tissue is identified and mobilized off the anterior surface of the psoas. Then the anterior surface of the psoas is cleared of loose areolar tissue in a cephalic direction to better expose the renal hilar elements using a combination of a 5-mm Maryland grasper (left hand) and, alternatively, a LigaSure (Covidien, Mansfield, MA, USA) 5-mm laparoscopic instrument or 5-mm dissector (right hand). The articulable instruments (Roticulator Endo Dissect and SILS Hand Instrument articulating grasper (Covidien, Mansfield, MA, USA) can be used if available.

2.1.5. Tumor identification

The Gerota’s fascia is incised and the kidney defatted at an adequate distance from the kidney mass. The mass is identified (Fig. 4) and circumferentially marked by electrocautery [12].

Fig. 1 – Enhanced computed tomography scan showing an exophytic, very small, renal mass of left kidney approached by unclamped laparoendoscopic single-site partial nephrectomy.
Fig. 3 – An external view of the operative field showing the LigaSure (Covidien, Mansfield, MA, USA) in the right hand and the laparoscopic 10-mm Peanut retractor (Covidien, Mansfield, MA, USA) in the left hand.

Fig. 2 – Single-port devices used: (A) the SILS Port (Covidien, Mansfield, MA, USA); (B) the Quadport (Advanced Surgical Concepts, Bray, Ireland); (C) the Endocone (Karl Storz, Tuttlingen, Germany); (D) the OCTO Port (Darim Corp., Seoul, Korea).

Fig. 4 – Identification of the exophytic anteriorly located small renal mass.
2.1.6. Tumor excision
The 5-mm bipolar scissors (right hand) are used to excise the tumor during normal renal perfusion (Fig. 5) with a standard laparoscopic aspirator in the left hand. After the excision of the mass, the parenchymal hemostasis is achieved by bipolar electrocautery, Tabotamp bolster (Johnson & Johnson, New Brunswick, NJ, USA), separate parenchymal stitches, and FloSeal (Baxter Inc, Deerfield, IL, USA).

2.1.7. Tumor extraction and closure
The specimen is extracted from the port site entrapped in a 10-mm endoscopic bag. In few cases, a tubular drain is left in situ, and the fascia is closed with large absorbable sutures. The skin is closed with absorbable sutures (Fig. 6).

3. Results

3.1. Demographic data
Twenty-one patients (mean age: 58.4 ± 9.0 yr) underwent LESS-PN without ischemia. Based on the CT/MRI images, we recorded five, nine, and seven renal masses classified as PADUA score 6, 7, and 8, respectively. Complete demographic data are listed in Table 1.

3.2. Operative and postoperative data
Unclamped LESS-PN was successfully completed in all patients with a mean operative time of 111 ± 41 min. Disposable trocars were used in the majority of cases (76%). No patients required either conversion from an unclamped technique to an ischemic one or conversion to open surgery. No intraoperative vascular or bowel injuries occurred. One additional 3-mm port was used in one case for liver suspension and in one case for left colon mobilization. In these cases, the additional trocar was placed subcostally, 1 cm laterally to the xiphoid process. One additional 5-mm port was used in two cases of left tumor to aid the suturing of renal parenchyma. The trocar was placed in the left lateral abdominal wall (midpoint between the multichannel trocar and the left anterior superior iliac spine).

Three cases of left tumor (14%) were converted to standard laparoscopy (adding two 5-mm ports) to expose a posterior interpolar mass (one case) and to achieve a satisfactory hemostasis (two cases). In these cases, the additional trocars were placed to create the standard triangulation of the instrument, leaving the multichannel trocar as a simple trocar for the optic. No association was found between the tumor location and PADUA score with regard to the need of additional trocars.

The articulating instruments were used in three cases; in all the others, only standard straight devices were used.

Table 1 – Demographic data

<table>
<thead>
<tr>
<th>Patients, n</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>58.4 ± 9.0</td>
</tr>
<tr>
<td>Sex, female/male ratio</td>
<td>7/14</td>
</tr>
<tr>
<td>Body mass index, kg/m²</td>
<td>25 ± 2</td>
</tr>
<tr>
<td>Left/right kidney, no.</td>
<td>11/10</td>
</tr>
<tr>
<td>Asymptomatic/symptomatic ratio, no.</td>
<td>20/1</td>
</tr>
<tr>
<td>ASA score</td>
<td>2.1 ± 0.4</td>
</tr>
<tr>
<td>PADUA score</td>
<td>7.1 ± 0.7</td>
</tr>
</tbody>
</table>

ASA = American Society of Anesthesiologists class risk.

* Values expressed as mean plus or minus standard deviation unless otherwise specified.
Table 2 - Operative and postoperative data

<table>
<thead>
<tr>
<th>Action</th>
<th>Patients, no.</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clavien grade 2: acute gastritis</td>
<td>1</td>
<td>Proton pump inhibitors</td>
</tr>
<tr>
<td>Clavien grade 3a: urinary fistula</td>
<td>1</td>
<td>Ureteral stent placement</td>
</tr>
<tr>
<td>Clavien grade 4: cerebral stroke</td>
<td>1</td>
<td>Admission to stroke unit</td>
</tr>
<tr>
<td>Overall complication rate (%)</td>
<td>3/21(14)</td>
<td>–</td>
</tr>
</tbody>
</table>

Operative time, min | 111 ± 41
Estimated blood loss, ml | 196 ± 195
Transfusion rate, % | 0 (0)
Hemoglobin decrease, g/dl | 2.02
Creatinine increase, mg/dl | 0.03
eGFR decrease, ml/min | 2.7
POD of oral intake, d | 1.9 ± 1
VAS (1–10) in POD1 | 2.1 ± 1.2
Length of stay, d | 4.4 ± 1.9
Use of one additional 5-mm port, no. (%) | 4 (19)
Conversion to standard laparoscopy, no. (%) | 3 (14.2)
Conversion rate to open surgery, no. | 0
Skin incision length, cm | 3.4 ± 0.4
Cosmetic outcome, no. (%) | Unsatisfied 0, Satisfied 7 (33), Very satisfied and enthusiastic 14 (66)
Follow-up, mo | 17 ± 11.5
Tumor recurrences, no. | 0
Patients alive at follow-up visit, no. (%) | 20 (95.2)

Table 3 - Postoperative complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Patients, no.</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clavien grade 2: acute gastritis</td>
<td>1</td>
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<td>Clavien grade 4: cerebral stroke</td>
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<td>Admission to stroke unit</td>
</tr>
<tr>
<td>Overall complication rate (%)</td>
<td>3/21(14)</td>
<td>–</td>
</tr>
</tbody>
</table>

eGFR = estimated glomerular filtration rate; POD = postoperative day; VAS = visual analog scale.

Values expressed as mean plus or minus standard deviation unless otherwise specified.

Discussion

In recent years, the introduction of advanced equipment and technical modifications put the concept of triangulation in the shade and shed a light on LESS as a new, alternative, laparoscopic approach [13].

The entire spectrum of urologic procedures has been performed and described using a LESS approach, including ablative and reconstructive surgery, as described in the first, worldwide, multi-institutional LESS database [14]. After the first report by Aron et al. on their initial experiences with ischemic LESS-PN, few studies have been reported on the problems and challenges encountered during LESS-PN [5,15–20].

Recently, a review of the literature focused on this kind of surgery [6], showing that it was exclusively performed by very skilled laparoscopic surgeons. Of the 110 cases described in the literature (62 robot-assisted), the authors noted that only very small masses (<3 cm) were approached (mean operative time: 179 min; mean EBL: 249 ml). Eighteen percent of the cases were performed without ischemia; in the others, the mean warm ischemia time was about 21 min (transfusion rate: 7.5%). The occurrence of severe complications was generally low (5.4%); moreover, in a high percentage of the cases, additional trocars were added [6].

The current study aimed to describe in detail the technique of LESS-PN without ischemia and to report early oncologic and functional outcomes. Despite being considered essential to reducing blood loss and clearly identifying the tumor bed, hilar clamping during PN is not always mandatory [21]. To maximize the preservation of healthy renal parenchyma, we carefully selected the 21 patients to whom we offered this kind of less invasive, laparoscopic approach.

In our series, unclamped LESS-PN was completed successfully, with a mean operative time of 111 min. These data are similar to other series in which the operative time ranged between 149 and 270 min [6]. Although the blood loss during unclamped PN tends to be greater than in the clamped counterpart, none of the patients required transfusions, albeit in presence of a mean blood loss of 196 ml and a mean hemoglobin level decrease of 2.02 g/dl. This issue is shared with other authors who reported a mean EBL between 100 ml (robot-assisted LESS) and 475 ml [6]. The rates of using one additional port (19%) and of converting to standard laparoscopy (14%) seem high; additional trocars were added to help the surgeon in challenging situations. Moreover, these data overlap those reported in the literature [6,14] and suggest that early adopters of the technique have adhered to the principles of careful patient selection and safety [22].

The articulating instruments were only used in the initial three cases; thereafter, the surgery exclusively proceeded following the technique of parallel driving using straight instruments. In our opinion, there are several reasons that the chopstick technique [4] should be preferred over an
unceasing research of triangulation: the high costs, the difficult handling, and the lack of robust strength. The use of conventional laparoscopic instruments in a single-site fashion may represent a new point of strength for encouraging the LESS approach because the laparoscopic surgeon would not have to learn how to use articulating instruments.

In our cases, the decision for or against a nonischemic LESS-PN has been based mostly on tumor size, polar location, depth, and the proximity to the pelvis. Even if the PADUA score had never been adopted in deciding whether or not to perform a LESS procedure, the careful selection of cases is considered the key to success in NSS [5,6]. In the present series, the mean PADUA score was 7.1, suggesting a clear selection of patients at low risk for complications. In our opinion, this nephrometric scoring system could help the surgeon make the best choice and objectify a personal feeling, ensuring comparability between groups of patients undergoing PN by different approaches.

In this series, we recorded a 14% overall complication rate (Table 3). The most relevant was the occurrence of a cerebral stroke (Clavien grade 4) in a 60-yr-old, nonsmoking man with mild hypertension. Despite the severity of this complication, the common postoperative outcomes were extremely favorable and confirmed a fast recovery of bowel function (mean POD of oral intake: 1.6) and painless mobilization (mean VAS on POD1: 2.1) with a short LOS (4.4 d). The early oncologic and functional outcomes, the high level of patient satisfaction with the scar, and the limited abdominal wall trauma (no wound infection, hernia, or wall hematoma) confirmed the safety and feasibility of LESS-PN without ischemia.

There are a few limitations to the present study that should be mentioned. First, this study reflects the initial experience of a single surgeon in one center. To demonstrate the advantage of a new technique over a standard one, a randomized surgical trial is theoretically ideal. Unfortunately, it cannot be designed and realized until LESS has sufficiently evolved to warrant a methodologically correct assessment [23]. The significant advantages of laparoscopic procedures over their open-surgery counterparts have been demonstrated within a couple of decades; the hypothetic advantages of LESS over standard laparoscopy probably will be proven in less time. The lack of sufficient demonstration of the superiority or equivalence of LESS over conventional laparoscopy could be explained by the young age of LESS. Future studies are expected, including larger series and long-term follow-up to define the oncologic safety of this technique.

Second, the careful selection of the renal masses we made in this initial experience could hinder the transferability of our findings to the wider field of the NSS options. Only the continuation of experience with more complex cases will clarify if LESS-PN will really overlap the laparoscopic counterpart.

Third, we used a subjective evaluation of the scar and patient’s pain. Even if the use of validated and reproducible questionnaires should be encouraged, to the best of our knowledge, no LESS-specific tools have been developed. Nevertheless, the rare comparisons between LESS and conventional procedures have shown less analgesic consumption and a higher satisfactory pain scores in the LESS group [24,25].

Fourth, even though we tested several multichannel trocars, no direct comparisons were done due to the small number of cases performed with each trocar. Moreover, the surgeon’s preference was slightly in favor of disposable devices because they provide a higher flexibility and degree of freedom. To the best of our knowledge, the value of a specific tool in terms of safety, cost effectiveness, ergonomics, and overall function has not been investigated.

5. Conclusions

LESS-PN without ischemia is technically feasible, provides encouraging surgical outcomes, and ensures subjective cosmetic satisfaction. This technique should be attempted in carefully selected patients with favorable features of tumor anatomy and performed by an experienced laparoscopic team. Further clinical studies with longer follow-up are needed to better define the true role of unclamped LESS-PN in minimally invasive renal surgery.

Author contributions: Francesco Berardinelli had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Schips, Cindolo, Berardinelli.

Acquisition of data: Berardinelli, Neri.

Analysis and interpretation of data: Cindolo, Berardinelli.

Drafting of the manuscript: Berardinelli, Cindolo.

Critical revision of the manuscript for important intellectual content: Schips, Tamburro.

Statistical analysis: Berardinelli, Cindolo.

Obtaining funding: None.

Administrative, technical, or material support: Berardinelli.

Supervision: Schips.

Other (specify): None.

Financial disclosures: Francesco Berardinelli certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: None.

Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at http://dx.doi.org/10.1016/j.eururo.2012.08.008 and via www.europeanurology.com.

References