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Laparoendoscopic Single-Site Radical Nephrectomy for Renal Cancer: Technique and Surgical Outcomes

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Abstract

Background: Laparoendoscopic single-site (LESS) surgery has been developed in attempt to further reduce the morbidity and scarring associated with surgical intervention.
Objective: To describe the technique and report the surgical outcomes of LESS radical nephrectomy (RN) in the treatment of renal cell carcinoma.
Design, setting, and participants: LESS-RN was performed in 33 patients with renal tumours. The indications to perform a LESS-RN were represented by renal tumours not greater than T2 and without evidence of lymphadenopathy or renal vein involvement.
Surgical procedure: The Endocone (Karl Storz, Tuttlingen, Germany) was inserted through a transumbilical incision. A combination of standard laparoscopic instruments and bent grasper and scissors was used. The sequence of steps of LESS-RN was comparable to standard laparoscopic RN.
Measurements: Demographic data and perioperative and postoperative variables were recorded and analysed.
Results and limitations: The mean operative time was 143.7 ± 24.3 min, with a mean estimated blood loss of 122.3 ± 34.1 ml and a mean hospital stay of 3.8 ± 0.8 d. The mean length of skin incision was 4.1 ± 0.6 cm and all patients were discharged from hospital with minimal discomfort, as demonstrated by their pain assessment scores (visual analogue scale: 1.9 ± 0.8). The definitive pathologic results revealed a renal cell carcinoma in all cases and a stage distribution of four T1a, 27 T1b, and 2 T2 tumours. All patients were very satisfied with the appearance of the scars, and at a median follow-up period of 13.2 ± 3.9 mo, all patients were alive without evidence of tumour recurrence or port-site metastasis.
Conclusions: LESS is a safe and feasible surgical procedure for RN in the treatment of renal cell carcinoma and has excellent cosmetic results.

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1. Introduction

The idea behind the application of a minimally invasive technique like laparoscopy is to achieve the same result with the same safety for the patient as compared to open surgical procedures [1].

Typically, major laparoscopic surgery involves the use of several (three to five) ports inserted trans- or retroperitoneally [2]. Recent developments in laparoscopy have been directed towards further reducing morbidity and improving the cosmetic outcome. These include the use of minilaparoscopic 2-mm needle ports [3], natural orifices [4], and transumbilical access [5–7]. Laparoendoscopic single-site (LESS) surgery uses bent and articulating instrumentation introduced through either adjacent conventional trocars or a specialised multilumen port.

Although anecdotal reports of LESS are scattered through the literature of the past decade, it was not until recently

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that there was a surge in the use of LESS across urologic surgery [2,5–19].

In the current report, we present our technique and our preliminary experience with 33 patients who underwent LESS radical nephrectomy (RN).

2. Patients and methods

Between May 2009 and March 2011, 33 patients underwent LESS-RN for renal cancer. All patients gave written informed consent after being informed that the procedure would be attempted via a single incision and that additional incisions might be necessary.

A prospective institutional review board-approved datasheet was constructed for this study. The following data were collected: age, gender, body mass index (BMI), pre- and postoperative renal function, prior abdominal surgery, and specific comorbidities, American Society of Anaesthesiologists (ASA) score, tumour stage and grade, surgical margin status, specimen weight, operative time, and estimated blood loss (EBL). Additional collected data included intraoperative variables (number of additional ports), pre- and postoperative serum haemoglobin levels, transfusion data, conversion to open surgery or to standard laparoscopy, length of stay (LOS), postoperative pain evaluated on a visual analogue scale (VAS) score at discharge, incision length, and subjective scar satisfaction.

Both medical and surgical complications occurring at any time after surgery were captured, including during the inpatient stay as well as in the outpatient setting. They were classified as early (onset: <30 d), intermediate (onset: 31–90 d), or late (onset: >90 d) complications, depending on the date of onset. For late complications, those deemed to be related or possibly related to LESS were captured, regardless of how long after surgery the onset occurred.

All complications were recorded with a grade (1, 2, 3a, 3b, 4a, 4b, or 5) assigned according to the modified Dindo-Clavien classification [20].

One laparoscopic surgeon (F.G.), with experience of >200 conventional laparoscopic RNs, performed all procedures.

The indications to perform a LESS-RN were represented by renal tumours no greater than T2 and without evidence of lymphadenopathy or renal vein involvement, BMI <35 kg/m^2, and absence of health conditions precluding a laparoscopic procedure. Preoperatively, all the patients underwent sonography, computed tomography with contrast medium, or magnetic resonance imaging, if deemed necessary. Patients included in the study were not eligible for partial nephrectomy (infiltration of the renal vessels and/or of the pelvicalyceal system) or the patient decided to undergo a radical procedure to reach oncologic safety. In the latter cases, the patient decided between a laparoscopic partial or RN after a comprehensive discussion. If the patient decided to undergo the radical procedure and respected the indicated criteria, the possibility of a LESS-RN was proposed.

2.1. Surgical technique

The sequence of steps of LESS-RN is comparable to standard laparoscopic RN.

2.1.1. Preoperative preparation

A mechanical bowel preparation is not necessary. In contrast to open surgery, the motility of the intestine remains virtually unaffected in laparoscopic procedures, as evidenced by a constant serotonin level during and after surgery [1]. Prevention of thrombosis using low-molecular-weight heparin is mandatory. Single-shot intravenous antibiosis using a cephalosporin should be administered at the beginning of the procedure.

2.1.2. Anaesthesia

LESS-RN is performed under general anaesthesia. Intraoperative invasive monitoring involves an intra-arterial line, central venous pressure monitoring, electrocardiogram, and urine output. A recommended regimen is the induction using intravenous thiopental and isoflurane as the inhalation agent. Following the induction of general anaesthesia, a nasogastric tube and transurethral catheter are placed to decompress the stomach and bladder.

2.1.3. Operative setup and patient positioning

The patient is placed in the semilateral decubitus position with the side of the lesion elevated 60°. The ipsilateral arm is secured using an arm board and the contralateral arm is fixed beside the trunk and well padded to avoid lesions of neural structures. Additional fixation is done using cloth tapes across the hips and the legs. Great care should be taken to generously pad all rests and cloth tapes. When the patient is positioned securely, the table is rolled to a classical flank position to verify the stability of the system (Fig. 1).

The surgeon and the assistant stand to the contralateral side of the interested kidney (ie, renal tumour left, surgeon at the right side).

2.1.4. Instruments

The Endocone trocar (Karl Storz, Tuttlingen, Germany) is a specialised multilumen port with six 5-mm working channels, one 12-mm channel, and one 15-mm channel, which is essential for introducing larger instruments (eg, a 15-mm Endobag).

A 30° lens high-definition laparoscopic camera (Karl Storz, Tuttlingen, Germany) with a 5-mm diameter and 50-cm length was used in all cases. The laparoscope is inserted through one of the 5-mm channels and frees the 12-mm channel for insertion of instruments with a diameter >5 mm, such as 10-mm clips or a vascular Endo-GIA linear stapler. In all cases, a combination of bent (curved) and conventional laparoscopic (straight) instruments was used to perform all procedures (Table 1). The instruments were inserted through one of the 5-mm channels and the 12-mm channel of the Endocone.

2.1.5. Port placement

The operative table is moved back into dorsal supine position and a minilaparotomy (5 cm) is performed for the insertion of the Endocone. The fascia is fixed with a 2-0 Vycril suture. An Alexis small wound retractor (Applied Medical, Rancho Santa Margarita, CA, USA) is inserted and the Endocone is placed. Then the table is rolled to 60° (Fig. 2).

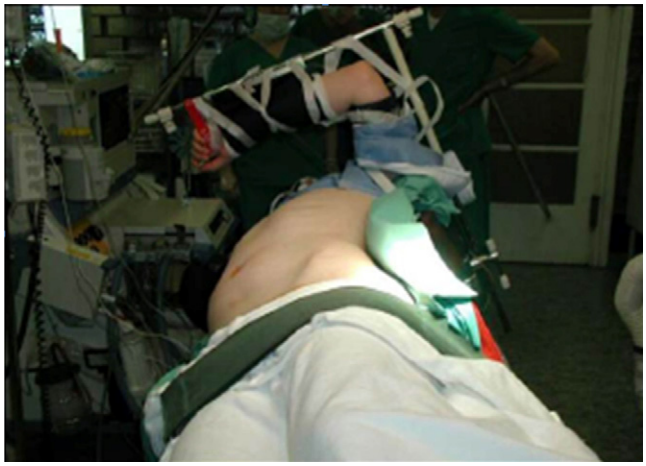

Fig. 1 – Patient positioning.

Table 1 – Toolbox for laparoendoscopic single-site radical nephrectomy: access devices, instruments, and optics

Category	Name	Main features
Access device	Endocone (Karl Storz, Tuttlingen, Germany)	The Endocone allows ergonomic placement of the valves for multiple telescope and instrument access, has a rigid seal cap, and is reusable.
Prebent instruments	S-PORTAL series (Karl Storz)	Preshaped rigid instruments with different profiles, S-PORTAL devices are reusable but offer fewer degrees of freedom.
Needlescopic instruments	Minilaparoscopy series (Karl Storz)	These instruments are 3 mm in diameter and 36 cm long. They are to be used with a 3-mm trocar with a silicone leaflet valve.
Straight instruments	Ligasure (Covidien, Dublin, Ireland)	This is a bipolar system that permanently fuses vessels $\leq$7 mm in diameter and tissue bundles without dissection or isolation.
Optic	Telescope Hopkins (Karl Storz)	This is a 30° lens high-definition laparoscopic camera with a 5-mm diameter and 50-cm length.

2.1.6. *Exposure of kidney (bowel reflection)*

During the performance of left nephrectomy, the line of Toldt is incised from above the spleen to the level of the iliac. Then the muscle psoas is identified and the colon is reflected medially. Incision of the splenocolic ligament follows to mobilise the spleen, colon, and pancreas. A curved forceps, held in the left hand, is used to expose the tissue and a curved monopolar scissor in the right hand is used to dissect the tissue and cut along the line of Toldt (Fig. 3).

Right nephrectomy starts with peritoneal incision carried cephalad above the hepatic flexure, including the right triangular and right anterior coronary vessels. The dissection of the line of Toldt is performed and colon retraction and division of all lateral ligaments follow with identification of the psoas muscle.

Further retraction of the liver may require an additional 3-mm trocar inserted directly through the skin (Fig. 4).

2.1.7. *Ureter mobilisation and mobilisation of the renal lower pole*

The middle portion of the ureter is identified medially to the psoas muscle. The curved forceps is used to grasp the ureter, and the curved scissor is used for dissection (Fig. 5).

2.1.8. *Identification and dissection of the renal pedicle*

Gerota's fascia is now opened and the lower pole of the kidney is mobilised. The lower pole is lifted laterally, and the hilum is under gentle tension to prepare the vessels. The renal vein and the renal artery are identified, prepared, and then dissected with vascular Endo-GIA staplers inserted through the 12-mm working channel (Fig. 6). Then the kidney is removed along with Gerota's fascia (including the perirenal fat).

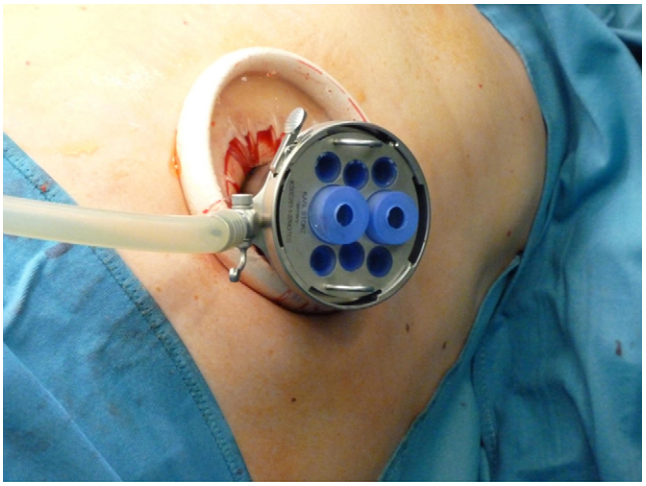

Fig. 2 – Placement of the Endocone (Karl Storz, Tuttlingen, Germany).

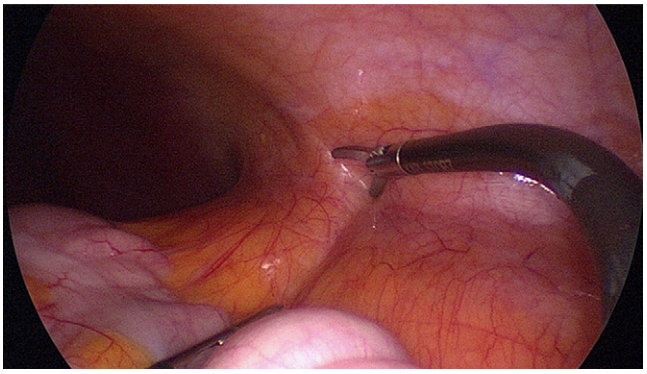

Fig. 3 – Incision of the Toldt's line.

Fig. 4 – Right-side laparoendoscopic single-site radical nephrectomy with an additional 3-mm trocar.

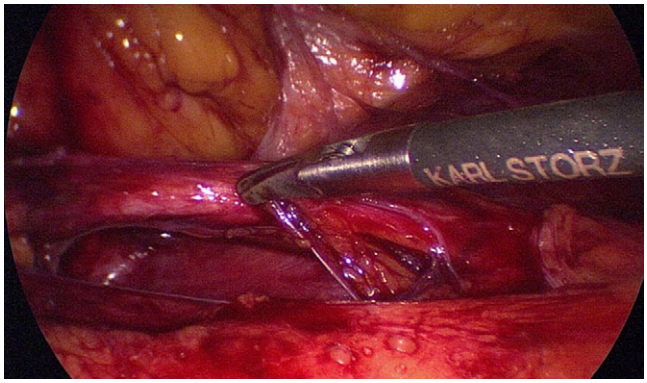

Fig. 5 – Identification of the ureter.

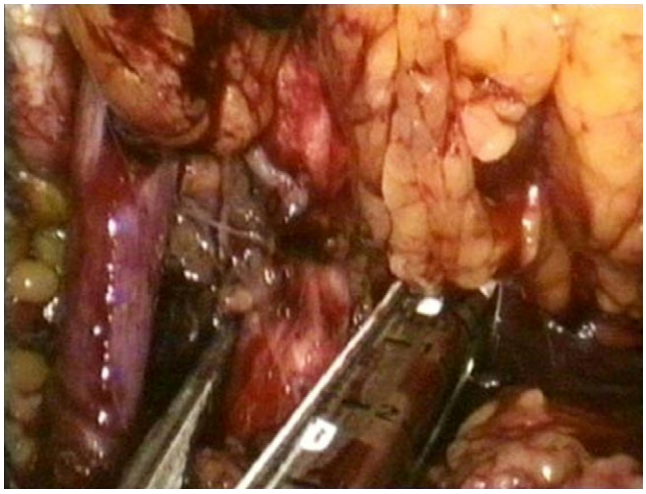

Fig. 6 – Stapling of the renal pedicle.

2.1.9. *Specimen removal*

An Endocatch bag is introduced into the abdominal cavity through the 15-mm working channel. For specimen removal, the rectus fascia incision is extended in a cranial and caudal direction and the intact specimen is removed through the umbilicus, without morcellation (Fig. 7). No drainage catheter is placed. The Endocone is removed, the fascia is closed with interrupted 2-0 Vycril suture, and the skin is approximated with an intracutaneous suture (Fig. 8).

Fig. 7 – Specimen removal.

Fig. 8 – Closure of the skin with an intracutaneous suture.

3. Results

Preoperative results are summarised in Table 2. The patient population was generally young (mean age: 55 ± 18 yr) and nonobese (mean BMI: 27.1 ± 2.1 kg/m^2) and had a mean preoperative ASA score of 2.4 ± 1.6.

All patients underwent a LESS-RN for enhancing renal masses with a median preoperative tumour size of 5.1 ± 1.4 cm.

The cohort included 11 patients who had undergone prior abdominal surgery (3 patients had undergone laparoscopic hysterectomy, 2 patients had a cholecystectomy, 2 patients had a splenectomy, and 4 patients had undergone a renal transplantation).

The mean operative time was 143.7 ± 24.3 min, with a mean EBL of 122.3 ± 34.1 ml and a mean hospital stay of 3.8 ± 0.8 d.

The mean skin incision length was 4.1 ± 0.6 cm and all patients were discharged from hospital with minimal discomfort, as demonstrated by their pain assessment scores (VAS = 1.9 ± 0.8) (Table 3).

Four complications were recorded—one early, two intermediate, and one late—for a mean complication rate of 12.1%. A detailed description is provided in Table 4.

Table 2 – Preoperative data

No of patients	33
Age, yr	55 ± 18
Gender (female/male ratio)	1.5
Body mass index, kg/m^2	27.1 ± 2.1
Left/right kidney, no.	24/9
Preoperative tumour size, cm	5.1 ± 1.4
Mean ASA score	2.4 ± 1.6

ASA = American Society of Anaesthesiologists.

Table 3 – Intra- and postoperative laparoendoscopic single-site radical nephrectomy data

No. of patients	33
Operating time, min, mean	143.7 ± 24.3
Blood loss, ml, mean	122.3 ± 34.1
Transfusion rate, %	3
Haemoglobin decrease, mmol/l	1.4 ± 0.8
Creatinine increase, μmol/l	15.7 ± 8.8
Days to postoperative oral intake, no.	1.0
VAS (1–10) at discharge, mean	1.9 ± 0.8
Analgesic requirement, mg, mean	9.8 ± 6.2
Length of stay, d, mean	3.8 ± 0.8
Use of one additional 3-mm port, no. (%)	9 (27.3)
Skin incision length, cm, mean	4.1 ± 0.6
Conversion rate to conventional laparoscopy, % (no. of patients)	3 (1)
Conversion rate to open surgery, mean	0
Convalescence time, d, mean	17.3 ± 9.6
Patients with tumour recurrence and port-site metastasis, no.	0

VAS = visual analogue scale.

Table 4 – Complications after laparoendoscopic single-site radical nephrectomy

Complication	Patients, no.	Action
Clavien 1	1	–
Flank pain	1	Analgesia
Clavien 2	1	–
Postoperative anaemia	1	Transfusion
Clavien 3b	2	–
Postoperative incisional hernia	1	Surgical repair
Lesion of the bowel	1	Surgical repair
Mean complication rate (%)	4/33 (12.1)	–

The definitive pathologic results revealed a renal cell carcinoma in all cases with a stage distribution of four T1a (in the native kidneys of transplant patients), 27 T1b, and 2 T2. Twenty-three tumours were centrally localised, nine were located on the lower upper pole, and one was located on the upper pole of the kidney, requiring an adjunctive adrenalectomy.

All tumours were organ-confined with negative surgical margins (Table 5).

At the first postoperative visit, all patients completed an arbitrary questionnaire rating the cosmetic results (1: unsatisfied; 2: satisfied; 3: very satisfied; 4: enthusiastic).

Table 5 – Postoperative histopathologic results

Patients, no.	33
Kidney weight, g, mean	457.9 ± 106.3
Specimen size, cm, mean	11.7 ± 1
Tumour stage (no. of cases)	pT1a (4)
	pT1b (27)
	pT2 (2)
Tumour grade (Fuhrman classification)	Grade I (2)
	Grade II (3)
	Grade III (28)
Tumour size, cm, mean	5.7 ± 1.2
Tumours/case, no.	2/2
	1/31
Surgical margins	Negative

Fig. 9 – Postoperative appearance of surgical scar after laparoendoscopic single-site radical nephrectomy.

All patients were enthusiastic with the appearance of the scars (Fig. 9).

At a median follow-up of 13.2 ± 3.9 mo (range: 6–24 mo), all patients were alive without evidence of tumour recurrence or port-site metastasis.

4. Discussion

In recent decades, renal surgery has changed in ways never before imagined, with increasing incorporation of minimally invasive laparoscopic/robotic procedures.

Minimally invasive surgery aims to provide effective treatment of surgical diseases inside a body cavity while decreasing access-related morbidity, postoperative pain, and hospital stay, and enabling faster recovery, improved cosmesis, and patients' early return to work [1,21]. If, until the end of the 1990s, laparoscopy was critically attacked by most urologists, in the new millennium its value has gained widespread acceptance in urology. In 2007, for the first time, laparoscopic nephrectomy for renal cancer was defined as the standard of care for patients with T2 renal tumours [22].

Evolution of minimally invasive techniques has spurred an impetus in the surgical community to reduce the invasiveness of laparoscopic surgery. LESS has been developed in an attempt to further reduce the morbidity and scarring associated with surgical intervention.

The first two large series of urologic LESS were published in 2009 [23,24]. Since then, other early single-centre experiences have been reported, as have early comparative studies, albeit limited by small numbers, nonrandomised design, and lack of standardisation in the assessment of postoperative outcomes [13]. Overall, these series suggested that LESS was not inferior to conventional laparoscopy in terms of perioperative outcomes, and revealed an encouraging trend towards less postoperative pain and better cosmesis [14].

Raman et al. [7] were the first to report a case-control study comparing LESS with conventional laparoscopy. They

compared 11 LESS with 22 laparoscopic nephrectomies. According to the authors, the superiority of LESS over standard laparoscopic nephrectomy was "limited" to a mere subjective cosmetic advantage, even if this advantage was not specifically measured or quantified.

Autorino et al. [13] reported in a recent review of the literature that the outcomes after single-site surgery in non–high-risk patients seem to be comparable to conventional laparoscopy.

Recently, Tugcu et al. compared LESS simple nephrectomy and conventional laparoscopic simple nephrectomy [25]. Time to return to normal activities was reduced in the LESS group and all patients undergoing LESS were very pleased with cosmetic outcome.

Actually, many institutions have made a safe stepwise transition from standard laparoscopy to LESS for select indications. However, LESS has not replaced standard laparoscopy, even at high-volume institutions performing the technique [19,23,26].

Over the last few years, we have helped further the development of surgical instruments for LESS surgery to reduce the chief technical problems associated triangulation of the instruments, that is, internal and external instrument collision.

We used the Endocone port for all procedures. Although this port has a metal structure, it does not interfere with the instruments when they are inserted through the two lateral 5-mm channels of the trocar. LESS-RN was feasible and safe with the latter combination, with a mean complication rate of 12.1%, which is comparable to that reported in the literature [13,14,17,18].

The limitation of this study was represented by the short follow-up. The oncologic safety of LESS must be investigated. If the first LESS studies focussed on reporting surgical outcomes, we expect future studies to report long-term follow-up after LESS to evaluate its oncologic feasibility.

One additional trocar was used in 27.3% of cases in the present series and one might argue that this represents a major bias. In general, we embrace the concept that patient safety comes first. According to current terminology [13,27–29], the use of an extra 2–3-mm trocar is still considered as LESS. When this is a 5- or 12-mm trocar, the procedure has been defined by some as *reduced port* laparoscopy. Of course, when more than one additional trocar is used, the procedure becomes standard laparoscopy. In a recent multi-institutional study [14], use of an additional port occurred in 23% of cases, with an overall conversion rate of 20.8% (15.8% to reduced-port laparoscopy, 4% to laparoscopy, and 1% to open surgery).

Finally, one might argue that, similar to drug evaluation, any new surgical technique should be compared to the original one before one can draw any conclusions concerning its benefits. In this analysis, no control group (ie, standard laparoscopy) was considered; this was outside the scope of the present manuscript. Thus, the actual benefits of LESS compared to standard laparoscopy remain to be proven and further clinical validation is expected.

LESS-RN still represents a demanding surgical procedure. The lack of triangulation of conventional instruments due to their parallel insertion, with consequent instrument collision, represents one of the most important problems for the surgeon, who requires a prior great experience with conventional laparoscopy, as stated in the literature [2,5–7,12–14,17–19,23–25].

In a recent multi-institutional study, Greco et al. [17] demonstrated that malignant disease at pathology represents a predictive factor for complications after LESS for upper urinary tract surgery. Thus, surgeons approaching LESS should start with benign diseases in patients with low surgical risk to minimise the likelihood of postoperative complications.

5. Conclusions

LESS is a safe and feasible surgical procedure for RN in the treatment of renal cell carcinoma, and has excellent cosmetic results. More prospective studies with long follow-up are needed to investigate the oncologic safety of the LESS in the therapy of urologic malignant tumours.

***Author contributions*:** Francesco Greco 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: Greco, Veneziano.
Acquisition of data: Greco, Kawan, Hoda.
Analysis and interpretation of data: Greco, Wagner, Mohammed.
Drafting of the manuscript: Greco.
Critical revision of the manuscript for important intellectual content: Greco, Fornara.
Statistical analysis: None.
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Supervision: Fornara.
Other (specify): None.

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Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at doi:10.1016/j.eururo.2011.10.002 and via www.europeanurology.com.

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