Symposium

Laparoendoscopic single-site surgery and cancer

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ABSTRACT

Objectives: To perform a survey of the current state of laparoendoscopic single-site surgery (LESS) and its implementation in the treatment of malignant disease of the urinary tract. Although it is a recent development in the field of laparoscopic surgery with still unproven long-term results, LESS may prove to be more commonly performed in the coming years while managing urologic cancer patients.

Materials and Methods: A PubMed search was conducted using the key words laparoendoscopic single-site surgery, LESS, urologic cancer. Relevant articles were reviewed for data on the management of urologic malignancy with LESS.

Results: The first articles describing LESS for urologic cancers were published in 2007. Since then, published experience with this technique has increased. LESS has been implemented as an alternative to conventional laparoscopic surgery and open surgery for the treatment of major urologic cancers. The proposed advantages of LESS are the aesthetic benefit of a single incision and a quicker and less painful recovery. Disadvantages are the lack of instrument triangulation, instrument clashing and the steeper learning curve. As this is a fairly recent technical innovation, long-term functional and oncological results for LESS have not yet been published.

Conclusions: LESS is a novel technical advance over conventional laparoscopic surgery, and it can be successfully used in the treatment of patients with urologic cancers. Published data support the feasibility and safety of LESS interventions for major urologic cancers, and newer data may assist in finding LESS's ultimate position among therapeutic options for patients with urologic malignancies.

Key words: Laparoendoscopic, laparoscopic surgery, laparoendoscopic single-site surgery, single-site, urologic cancer

INTRODUCTION

Laparoendoscopic single-site surgery (LESS) is an emerging technique in the treatment of tumors of the genitourinary system. Extensive publication since the first report of a LESS nephrectomy in humans in 2007[1] has shown that any operation that can be performed by conventional laparoscopy can be reproduced by LESS. The use of LESS in all areas of urologic surgery has been presented in a recent multi-institutional review, and in fact, has shown that the some of the most common applications of LESS in urology are in the treatment of tumors of the upper urinary tract.[2] Due to the recent introduction of this technique, crucial long-term oncological outcomes are not currently available, and there is a lack of standardization as to the instrumentation needed, port types used, and access methods. Future studies should add significant information to these important aspects of LESS.

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MATERIALS AND METHODS

A PubMed search was conducted using the key words laparoendoscopic single-site surgery, LESS, urologic cancer. Relevant articles were reviewed for data on the management of urologic malignancy with LESS.

Advantages and disadvantages of laparoendoscopic single-site surgery

LESS offers potential advantages to patients, making it an attractive option in well-selected cases. The intuitive strength of LESS is its cosmetic advantage. Obviously, there is a smaller amount of scars, which are practically invisible when placed in the umbilical fold. Other claimed advantages of LESS are the potential for less blood loss, less

postoperative pain, and faster recovery and return to daily activities. Disadvantages of LESS in brief are the lack of instrument triangulation leading to a greater difficulty in performing operative tasks and the steeper learning curve. Previous extensive abdominal surgery and a BMI (Body Mass Index)> 30 should preclude patients from LESS, especially in the beginning of a center's experience.[3]

Furthermore, there is a need for the standardization of instrumentation in LESS. LESS has been performed with conventional laparoscopic instruments, pre-bent instruments, and flexible instruments [Figure 1]. A comparison[4] among these types of instruments revealed in an experimental setting that pre-bent instruments were associated with better maneuverability and provided for faster interventions. There is also a multitude of access ports available in the market, each with its own advantages and disadvantages [Figure 2].

laparoendoscopic single-site surgery for malignant disease

Conventional laparoscopic adrenalectomy is the gold standard for the treatment of benign tumors.[5] As compared to open surgery, laparoscopic adrenalectomy offers better outcomes in convalescence, hospital stay, cosmesis[6] and blood loss.[7] Single-site adrenalectomy has been reported, and has become more frequent as the technique evolves.[2] The role of laparoscopic surgery for malignant adrenal tumors, however, has not yet been definitely established, and there is even less data for LESS. To date, there are no reports of LESS for malignant adrenal tumors.

Single-site radical nephrectomy was initially reported in 2007 by Raman *et al*.[8] Currently, single-site radical nephrectomy has become a viable choice for renal tumors[9] without lymph node involvement or distant metastases. Conventional laparoscopic radical nephrectomy is the standard choice for T1 and T2 tumors and a feasible choice in strictly selected T3 patients. Taking this into account, LESS nephrectomy could theoretically be performed on patients with the same tumor stages. However, current limitations of the instrumentation available and lack of experience may render LESS nephrectomy exceptionally difficult if not impossible in large tumors (>10 cm, T2) or with involvement of perinephric tissues or veins (T3). As of June 2011, 210 cases of LESS radical nephrectomies have been published,[2] including the larger series presented by Stolzenburg *et al*.,[10,11] Desai *et al*.,[12] and White *et al*.,[13] confirming the feasibility of this technique. Although there are differences in the type of port and instruments used, and differences in the abdominal access technique, intraoperative and postoperative results are overall similar except for a case of positive margins in the White *et al*. series. Estimated blood loss of <200 ml, no necessity for open conversion and minimal other intraoperative complications are shared characteristics of these four larger series. In a follow-up to their previous studies, Stolzenburg and colleagues[14] relate their more extensive experience with 42 patients undergoing radical nephrectomy. Two cases were converted to conventional laparoscopic technique, by the addition of an extra 5-mm port. There were no open conversions, and complications were infrequent. One case of bowel injury occurred intraoperatively, and in the postoperative period, there was one case of deep venous thrombosis, one case of bleeding managed conservatively and one case of prolonged ileus. More recently, comparison studies between conventional laparoscopic and LESS radical nephrectomy have been published. Park *et al*., compared 19 cases of LESS radical nephrectomy with 38 cases of conventional laparoscopic radical nephrectomy, and found significant advantages for LESS in regards to postoperative pain outcome and length of stay in hospital. No significant differences were found in mean operative time, estimated blood loss and complication rate among both groups.[15]

LESS partial nephrectomy (LESS PN) is a significantly challenging procedure, but feasible in experienced centers [Table 1]. Larger series have appeared as of 2008, and 127 cases have been published as of June 2011.[2] Transabdominal or retroperitoneal access has been described, along with the use of various types of entry ports. Aron *et al*.,[16] describe their initial experience with LESS PN on five patients. In one of the cases, an extra 5-mm port was placed, the other four were completed through a single port. Median warm ischemia time was 20 min, median operative time was 270 min with an estimated blood loss of 150 ml. No patients had positive tumor margins. The significant surgical

Table 1: Single-center series on LESS partial nephrectomy

	No. of patients	Average operative time	Average warm ischemia time	Estimated blood loss	Complications
Aron *et al*.[16]	5	270 min	20 min	150 ml	One placement of extra port
Kaouk and Goel[17]	5	160 min	no clamping	420 ml	One conversion to standard laparoscopy, one clamping of renal vessels for hemostasis, one positive surgical margins
Bazzi *et al*.[18]	14	178 min	no clamping	148 ml	One conversion to open PN due to abdominal adhesions
Cindolo *et al*.[19]	6	148 min	no clamping	201 ml	One conversion to standard laparoscopy due to excessive bleeding
Derweesh *et al*.[20]	4	177 min	24 min	112 ml	One conversion to open PN due to failure to progress (prior abdominal surgery and radiation therapy)

challenge is clearly reported in the article. Kaouk and Goel[17] enrolled five patients for LESS PN without clamping of the renal vessels. A Harmonic scalpel was used for the resection of the tumor, and hemostasis was secured by argon beam coagulation and tissue adhesives. One of the patients required conversion to standard laparoscopy for hemostatic control and also required clamping of the renal vessels for 16 min. Mean operative time was 160 min and estimated blood loss for these cases was 420 cm^3, and one patient in the series had positive tumor margins. Another study of LESS PN without vessel clamping involved the use of a bipolar radiofrequency coagulation device.[18] Fourteen patients underwent LESS PN with a mean operating time of 178 min and an estimated blood loss of 148 ml. All patients had negative margins, and one case had to be converted to open non-ischemic partial nephrectomy due to significant abdominal adhesions. This study also recruited 60 patients for conventional laparoscopic partial nephrectomy, providing for a comparison between the two techniques. Comparable results were shown for the two groups, in terms of major intra- and postoperative outcomes. Cindolo and co-workers[19] performed LESS PN without clamping in solitary exophytic tumors, and report one conversion to standard laparoscopy. In a study of four LESS partial nephrectomies, Derweesh and colleagues[20] report a mean warm ischemia time of 24 min and one conversion to open PN.

In the beginning of one's experience, as with conventional laparoscopic partial nephrectomy, LESS PN should be performed in rigorously selected patients. Small (<4 cm, T1a) exophytic peripheral lesions in the lower pole are ideal for initial attempts at LESS PN. Centrally located, larger lesions adjacent to the hilum or collecting system may provide a significant challenge to completion of the procedure. Renal vessel clamping may be omitted by experienced surgeons, but at a higher risk of increased blood loss and possible conversion to standard laparoscopy or open surgery. In series which performed vessel clamping, warm ischemia times for LESS partial nephrectomy are comparable to conventional laparoscopic PN.

LESS nephroureterectomy (LESS NU) has also been shown to be feasible, with 39 cases published worldwide.[2] A transabdominal or retroperitoneal approach may be used to perform the resection of the kidney and ureter. The bladder cuff must be dissected through a separate incision if using the retroperitoneal access. If using a transperitoneal approach, the most common method of dissecting the bladder cuff is through a separate Pfanenstiel or Gibson incision—there is a large series reporting cuff dissection through the single incision.[21] The patient is placed in a lateral flank position, and it is possible to reach the kidney, lower ureter and bladder cuff through the same single incision and without patient repositioning. Experience has been mostly gained from three series of LESS NU along with individual reports. Desai *et al.*,[12] initially performed LESS NU in two patients,

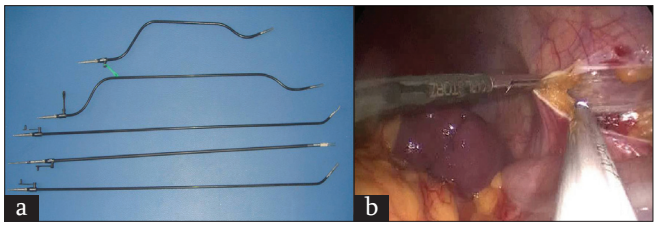

Figure 1: (a) Curved (pre-bent) instruments have been developed in an attempt to improve intra-operative ergonomics. More recently, curved instruments with extra-long shafts have been introduced. These instruments have been used in the performance of hybrid transvaginal laparoendoscopic single-site nephrectomy. The transvaginal access requires instruments with extra-long shafts in order to reach the kidney. (b) Combination of instruments is recommended while performing LESS. A pre-bent instrument provides tissue retraction while a straight instrument is used for dissection

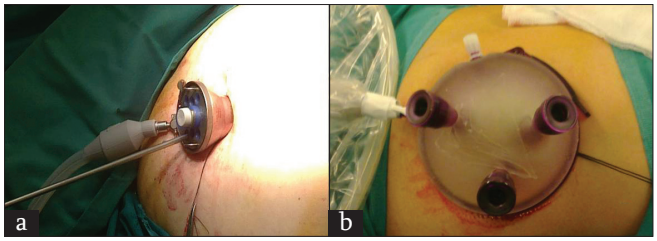

Figure 2: The development of new more advanced ports for single-port access was a significant contribution of LESS in the field of surgical instrumentation. These multi-lumen ports allow the insertion of multiple instruments through the same incision. (a) The Endocone (Karl Storz, Tuttlingen, Germany) multi-lumen port is reusable. (b) The Gelpoint (Applied Medical, Rancho Santa Margarita, CA, USA) is disposable

with bladder cuff excision and repair done with the aid of a cystoscope and a laparoscopic endostapler. In one of the patients, an extra 5-mm port was necessary. Operative times were 90 and 200 min. No major postoperative complications were reported. A larger series was published by White and co-workers[22] with seven patients undergoing LESS NU. In this series, mean operative time was 198 min and estimated blood loss was 396 ml. One operation had to be converted to conventional laparoscopic nephroureterectomy. The largest series so far has been presented by Lee *et al.*,[21] with 10 cases of LESS NU. In one of the patients (T3N2) an extension of the umbilical incision was necessary to remove hilar lymph nodes, and in another patient (T2N0), a Gibson incision was performed to aid in the dissection of the distal periureteral adhesions. All other patients had bladder cuffs dissected through the same single incision. Mean operative time was 255 min and estimated blood loss was at 260 ml. Duration of stay was 4.75 days on average and urinary catheters were removed on the seventh day.

LESS radical prostatectomy is also being performed at an increasing rate since the early years (2007-2008) to the later years (2009-2010) of the LESS experience. A total of 25 cases have been published,[2] with 5 published in the early years and 20 in the latter years. The earliest series, of four patients, was published by Kaouk and colleagues[23] in 2008. Access was through a transperitoneal umbilical port, and

all cases were completed successfully. Flexible instruments were used to facilitate suturing. Mean operative time was 285 min, where 3.25 h were dedicated to the excision of the prostate, and 1.1 h to the creation of the vesicourethral anastomosis. Estimated blood loss was 288 ml and patients' stay was of 2.5 days on an average. There was one case of a rectourethral fistula noticed at two months after the surgery. Two patients had positive surgical margins. Follow-up was performed at 18 weeks, and PSA (Prostate Specific Antigen) was undetectable in all four patients, and three of the four patients used none to one incontinence pad daily. In the paper, the authors stress the difficulty of suturing in the pelvis, due to the naturally narrow space, lack of triangulation and clashing of LESS instruments. Perhaps due to the initial difficulties of this operation and the dominance of robotic-assisted laparoscopic prostatectomy as a minimally invasive procedure, very few centers have trials on LESS radical prostatectomy. Most of the more recent literature on the matter refers to robotically assisted LESS radical prostatectomy, as it is believed that the use of the robotic platform might alleviate some of the inherent problems of LESS.

The least performed oncological single-site surgery is radical cystectomy. The complexity of the operation leads to very long operative times. Studies at the present time are mostly feasibility reports. In total, 18 patients have undergone LESS radical cystectomy. Results for the earliest series[24] with three patients (two males, one female) performed in 2007 and their two year follow-up are already available. Surgery was performed through a single umbilical port, and urinary diversion was performed extracorporeally through a Bricker ileo-ureteral anastomosis. Articulating needle drivers were used for dorsal venous complex ligation and a flexible laparoscope was held by the assistant to minimize instrument clashing. Operative time only for the extirpative portion of the procedure was 315 min on an average, and estimated blood loss was 217 ml. Patients were discharged on the sixth postoperative day on an average. All patients had negative surgical margins and negative lymph node biopsies. No recurrence or metastases were detected on the two-year follow-up.

The largest series appearing on LESS radical cystectomy was published by Lin and co-workers, with 12 patients.[25] Salient points of technique are the extracorporeal creation of an ileal neobladder and suture of the ileourethral anastomosis with extracorporeal knots. Median operative time was 383 min and the estimated blood loss was 150 ml. Mean hospitalization time was 15.3 days. No positive margins were encountered on histopathologic examination of the specimens, and at their latest follow-up (average follow-up time of 16.1 months), all patients were found to be without recurrence or metastases.

The future of LESS may be its implementation together with robotic assistance, in order to overcome issues of triangulation and difficulty in performing complex surgical maneuvers. This seems to be a trend in single-site surgery, where more recent reports describe the inclusion of the DaVinci™ platform in LESS. After performing 51 robotic LESS (R-LESS) procedures at the Cleveland Clinic Foundation, Spana *et al*.,[26] believe that robotic assistance is probably the future of LESS. Their conclusion is based on the claimed gentler learning curve of R-LESS, aid in triangulation and intracorporeal suturing, and the market pressures of increased robotic usage in urological surgery. An overview of the current status of R-LESS by Rane and Autorino[27] also stresses the advantages of robotic assistance in LESS, but concedes that the current system is not yet ideal for single-site surgery. Currently, specialized instruments such as the VeSPA are being developed for the implementation of R-LESS. The VeSPA system works in conjunction with the DaVinci robot, and consists of a special multi-channel port and curved cannulae for the insertion of flexible instruments. A significant drawback is the lack of articulation of these instruments at the wrist.[28]

Apart from robotic assistance, other developments in instrumentation and technology may facilitate the implementation of LESS. Dedicated single-site surgery instruments, such as the SPIDER (Single Port Instrument Delivery Extended Reach, TransEnterix) platform, are already being used in the clinical setting.[29] In this study, Leveillee and co-workers describe the feasibility of performing a simple nephrectomy with the SPIDER instruments. The SPIDER system comprises a four-channel port (two for rigid instruments and two for flexible instruments) and specially designed flexible instruments. Once inserted inside the abdomen, the flexible instruments are deployed in a configuration that increases triangulation.

The demand for the development of such an array of specialized equipment is an indication of the difficulty of performing pure LESS. The implementation of LESS seems to have been hampered by its steep learning curve, the need for specialized equipment to facilitate surgery and its lack of absolute advantages over conventional laparoscopic surgery. Further studies and technological advances will serve to locate LESS's final position in the urologic armamentarium.

CONCLUSIONS

In general, it can be said that LESS has begun to surface as a feasible and safe operative choice for the oncological patient in urology. Although descriptions of all major oncological procedures have been published, long-term data is not yet available; thus a complete appraisal of LESS will depend on future studies and results. Robotic assistance will likely play an increasing role in the application of single-site surgery, and further technological advances may reshape the future of oncological surgery in urology.

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