Symposium

Upper tract urologic LaparoEndoscopic Single-Site surgery

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ABSTRACT

LaparoEndoscopic Single-Site (LESS) surgery has been developed as an extension of conventional laparoscopy to provide a minimally invasive option with fewer incisions, minimizing scars and potentially improving postoperative convalescence. These techniques have been adopted in the practice of urologic surgery, and largely employed to date for upper tract surgery by urologists in specialized centers with advanced laparoscopic practices. Herein, we review the current experience with upper tract urologic LESS surgery.

Key words: Kidney transplantation, LaparoEndoscopic Single-Site, laparoscopy, renal cell carcinoma, upper tract urothelial carcinoma, ureteropelvic junction obstruction

INTRODUCTION

History of LaparoEndoscopic Single-Site surgery in urology

Since the initial laparoscopic nephrectomy in 1991, the use of laparoscopy has grown tremendously for the treatment of urologic conditions.[1,2] The techniques and instrumentation have evolved over these two decades allowing for more advanced laparoscopic procedures on more complex pathology. These include development of new access trocars, advanced optics, and robotic devices to improve operative efficacy, minimize morbidity, and strive for superior cosmesis. LaparoEndoscopic Single-Site (LESS) surgery is a prime example of such advancements within the field of laparoscopy.

LESS as the natural progression of laparoscopy

Several aspects unique to LESS distinguish it from multiport, "conventional" laparoscopy of which LESS surgery is considered a natural extension. In a short time period, urologists have successfully employed LESS techniques for treatment of virtually all upper urinary tract pathologies that were previously treated using conventional laparoscopy.[3,4]

Of the cases reported in the literature to date, the largest experience of urologic LESS surgery has been in the upper urinary tract, specifically renal procedures.[5] Upper tract urologic LESS surgery consists of both extirpative and reconstructive procedures of the kidneys, adrenal glands, and ureters. The anticipated surgical volume of LESS procedures for nearly all renal and adrenal pathology is expected to be intermediate or high in volume.[6]

Different "single-site" access locations can be used, with the most common being the umbilicus. Other options include a transabdominal or retroperitoneal flank approach, a suprapubic or "mini-Pfannensteil" approach, or a Gibson incision retroperitoneal approach.[7-9] Either a specialized port or clustered conventional ports can be used to obtain access. Conventional laparoscopic techniques are generally followed, although modifications in technique and maneuvers unique to single-site surgery are employed.

The primary goal of LESS surgery is to provide equivalent surgical outcomes with improved cosmetic results. Current research seeks to clarify what, if any, peri-operative or convalescence-related benefits may be offered by minimizing the number of incisions and cumulative incision length used compared to conventional laparoscopy.[9] As technology continues to evolve, specifically in terms of robotics, single-site access will become more widespread across the globe and

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will continue to have expanding indications and outcomes' data to support its use.

Extirpative surgery

Less nephrectomy

LESS simple and radical nephrectomy have been performed for benign and malignant indications, respectively. Although different indications and operative goals are encountered, both employ similar surgical techniques as with conventional laparoscopy with minor modifications to overcome challenges of the single site.[10]

Since Rane and colleagues reported the first LESS nephrectomy in 2007, it has become the most commonly performed LESS urologic surgery.[11] The most common location for trocar placement is at the umbilicus, and in cases of simple nephrectomy for non-oncologic indications, morcellation of the specimen eliminates the need to extend the incision, maximizing the cosmetic outcome. Rane and colleagues described their initial experience with five LESS simple nephrectomies whereby morcellation allowed for a hidden scar within the anatomic folds of the umbilicus.[12] However, extension of the access site incision is necessary for radical nephrectomies and nephroureterectomies to allow for intact extraction of the kidney specimen.

Since the initial publications on LESS simple nephrectomy, LESS radical nephrectomy has been performed and reported with acceptable pathologic outcomes.[7,13,14] LESS radical nephrectomy has been described via both umbilical access as well as a Pfannenstiel incision.

In a series comparing LESS nephrectomy (both simple and radical) to conventional laparoscopic nephrectomy, Raman and colleagues report statistically equivalent operative times, postoperative analgesic use, length of hospitalization, and complication rates; the LESS cohort yielded lower estimated blood loss, however, the change in hemoglobin concentration was not statistically significant.[13] More recently, a randomized controlled trial comparing LESS versus conventional multiport laparoscopic nephrectomy demonstrated lower visual analog pain scores and decreased analgesic requirements for the LESS arm.[15]

LESS partial nephrectomy

Partial nephrectomy is considered a challenging operation even when performed by conventional multiport laparoscopy. Nevertheless, with attention to optimizing cosmesis, LESS partial nephrectomy has been demonstrated to be feasible and safe in select patients.[16] LESS partial nephrectomy has been described without accessory trocars,[7] while some utilize needlescopic accessory ports to aid in intracorporeal suturing in order to minimize the duration of warm ischemia and achieve a hemostatic renorrhaphy.[17]

Indications for conventional laparoscopic partial nephrectomy are expanding, now allowing for resection of select clinically staged T1b tumors, central, and hilar tumors.[18] With these expanded indications, modified techniques of laparoscopic partial nephrectomy are being utilized, including extirpation without hilar clamping.[19,20] Until recently, LESS surgery has been largely reserved for the strictest indications. However, the newest series of cases are expanding indications to include LESS partial nephrectomy for larger, more complex lesions as well as incorporating techniques to minimize or eliminate warm ischemia.[21] In the renal LESS series reported to date, LESS partial nephrectomy is performed in a highly select patient population with ideal body habitus, limited prior abdominal surgery, and favorable tumor size and location.

To date, the largest series of LESS partial nephrectomy are presented as a conglomerate experiences of LESS urologic procedures or admixed with robot-assisted LESS cases.[5,22,23] These reports demonstrate the feasibility, safety, and wide variety of renal masses that can be successfully resected with this novel technique.

LESS nephroureterectomy

Nephroureterectomy has also been reported as an extirpative application of LESS, used for the treatment of upper tract urothelial carcinoma.[7,24,25] Both retroperitoneal and transperitoneal approaches have been described, in each case requiring an extraction site accommodating the intact kidney and ureteral specimen. Often via the extraction site, added distal ureteral dissection or an open bladder cuff could be performed.[7,25,26]

Currently available studies reporting the oncologic outcomes of LESS nephroureterectomy are retrospective and descriptive. However, the literature available on LESS nephroureterectomy represents experiences from multiple centers worldwide indicating the concerted effort in this next realm of minimally invasive surgery.

Seo and colleagues reported their experience with LESS nephroureterectomy for upper tract urothelial carcinoma.[27] In their series, they performed LESS nephroureterectomy successfully on four patients via a periumbilical incision without conversion to standard laparoscopy or open surgery. They reported open management of the distal ureter and bladder cuff in three patients who had ureteral tumors. The fourth patient, with a renal pelvis tumor, had laparoscopic dissection of the distal ureter and bladder cuff transection with an endoscopic gastrointestinal anastomosis (GIA) stapler. All patients had pathologically complete resection with negative surgical margins and negative nodes. A second group reported LESS nephroureterectomy with formal bladder cuff excision successfully performed in two patients without additional trocar placement or conversion to open surgery.[28] Their data reveal similar

immediate pathologic outcomes with negative surgical margins. Chung and colleagues reported their experience with LESS nephroureterectomy with laparoendoscopic management of the bladder cuff.[29] Similarly, these two patients underwent LESS surgery without conversion and rendered complete resection with negative surgical margins.

These published studies as well as the reports of LESS nephroureterectomy embedded in composite LESS experiences have demonstrated feasibility and safety in performing this procedure.

LESS donor nephrectomy

The technique of LESS donor nephrectomy mimics the established methods of conventional laparoscopic living donor nephrectomy, described first in 1995.[30] Modifications unique to the LESS approach include the use of articulating or pre-bent instruments to overcome the challenges of single-site access and occasionally the use of bariatric instrumentation for adequate reach to the kidney, especially the upper pole and lateral aspects when performing a Pfannenstiel approach.

Consideration of the single-site location and specific access platform used is imperative since minimizing warm ischemia from the time of hilar ligation to specimen removal is essential. The use of a multiport device through a pre-established extraction site may be preferred since it allows for allograft extraction and rapid establishment of pneumoperitoneum over independently placed clustered trocars.

Single-site donor series have been reported by several different transplant centers.[31,32] In this population of healthy volunteer donors, the provision of a cosmetically superior result may be greatly valued by the patient, however, safety is of utmost concern. Hence, the surgeon should maintain a low threshold to convert to multiport, hand-assisted, or open surgery in cases with difficult anatomic approach or allograft procurement.[24]

A comparative study reporting a single-surgeon experience of six LESS cases matched to six conventional laparoscopic donor nephrectomies reported statistically comparable perioperative parameters, renal allograft characteristics, and postoperative pain.[33] Perioperative parameters evaluated and compared include operative time, warm ischemia time, estimated blood loss, and length of hospitalization. A matched pairs comparison of LESS donor nephrectomy to conventional donor nephrectomy revealed a quicker convalescence in the patient cohort undergoing LESS donor nephrectomy.[34] Parameters improved by the LESS approach included decreased time on oral analgesics, time off from work, and time to "100% recovery" as noted by patient questionnaires.

A randomized study comparing the outcomes of LESS versus conventional laparoscopy for donor nephrectomy found similar operative times, complication rate, and analgesia requirements. The LESS cohort of patients demonstrated comparatively decreased visual analog pain scores starting 48h after surgery as well as a shorter hospital stay. A longer warm ischemia time in the LESS cohort did not influence the overall period of ischemia nor did it alter rates of graft loss or estimated glomerular filtration rate (GFR) in recipients followed one year post transplantation.

LESS adrenalectomy

The first laparoscopic adrenalectomy was reported in 1992.[35] Since then, laparoscopic adrenalectomy has become the gold-standard treatment for resection of small to mid-size adrenal neoplasms.[36] An ongoing debate exists regarding the appropriateness of laparoscopy for the treatment of known or suspected adrenal cortical carcinoma.

One of the earliest LESS adrenalectomies was reported as a retroperitoneoscopic adrenalectomy via a 4.5-cm trocar without the use of insufflation.[37] In this series, 53 patients were treated successfully via this approach with only one patient requiring conversion to open surgery due to an adrenal vein injury. Since this initial report, several case reports, retrospective series, and protocolled cohort and randomized studies have reported various techniques, operative feasibility, and comparative outcomes of LESS adrenalectomy.[26,38-41] Also, the expansion to LESS adrenalectomy took shape with proof-of-concept investigations in porcine and human cadaver models with the goal of achieving "no visible scar" postoperatively.[42]

A contemporary series comparing LESS to conventional laparoscopic adrenalectomy reports equivalent perioperative outcomes and significantly less postoperative pain compared to conventional laparoscopic adrenalectomy.[41] Nine patients undergoing LESS adrenalectomy were compared to 17 patients undergoing conventional laparoscopic adrenalectomy matched by age, sex, and tumor size. Statistically, operative times, blood loss, and length of hospital stay were equivalent. The LESS cohort of patients required intravenous patient-controlled analgesia for a shorter period postoperatively.

Reconstructive surgery

LESS pyeloplasty

Since the development of laparoscopic pyeloplasty in 1993, this most common reconstructive upper tract urologic surgery has seen a significant shift to a minimally invasive approach.[43] Both dismembered and V-Y laparoscopic pyeloplasties have been performed in large series with reliable postoperative outcomes.[44,45]

Similar to patients undergoing living-donor nephrectomy, patients requiring pyeloplasty are commonly young and

healthy, without malignant pathology, where cosmesis may be of added concern. A cohort of LESS pyeloplasty patients demonstrated a younger mean and median age when compared to other operations at a single-institution experience of upper tract urologic LESS.[7] Heightened efforts to minimize the overall incision burden and subsequent appearance of cutaneous scars in this population seem appropriate.

All techniques and associated procedures can be performed via LESS, including dismembered pyeloplasty, V-Y pyeloplasty, pyeloscopy and stone extraction. Conventional laparoscopic salvage pyeloplasty has been reported with promising results.[46,47] However, to date, LESS pyeloplasty is reserved for idealized patients undergoing primary pyeloplasty for congenital ureteropelvic junction obstruction.

Postoperative outcomes have been reported for LESS pyeloplasty and compared to historical controls undergoing conventional laparoscopic pyeloplasty. Raman and coworkers reported a series of LESS pyeloplasty with comparable perioperative and functional outcomes.[48] In this study, all perioperative parameters were equivalent except the operative time and estimated blood loss, which were found to be significantly lower in the LESS cohort of patients.

A multi-institutional study by Schwartz and colleagues showed LESS pyeloplasty to be a safe option with success rates equivalent to conventional laparoscopic pyeloplasty.[49] In this series, the only clear benefit noted in the period of short follow-up was that of minimized incision size and postoperative scar formation although postoperative pain and analgesic requirements were not assessed to make a definitive statement on postoperative convalescence.

Future of LESS for upper tract urologic surgery

The future of LESS for upper tract urologic surgery depends on its continued demonstration of therapeutic efficacy and its reproducibility. From the series discussed in this review, it is evident that LESS—when employed in select cases in centers of excellence—can produce perioperative results that are similar to traditional laparoscopic surgery. Moreover, in LESS cases performed for cancer, early oncologic results are encouraging; longer follow-up is needed to establish LESS as an extension of traditional laparoscopic surgery.

The dissemination of LESS depends entirely on its reproducibility, both of its outcomes' data and its diffusion throughout training programs and into community centers. As pioneering centers become more experienced, exposure to LESS is being afforded to fellows and residents. To facilitate this, inanimate box trainers and electronic simulators that serve an adjunct role in laparoscopic training should be outfitted with LESS training modules. As experience with LESS increases, indications for its use will continue to expand, and more data will be generated from which we can further evaluate its efficacy.

Research and development remains a critical component for the advancement of minimally invasive urology. Motorized articulating instruments and robotic platforms will become available that will help overcome the inherent challenges of single-site surgery. Published reports have described the use of the daVinci Surgical System as an adjunct to LESS urologic techniques.[50,51] Currently under investigation are magnetic anchors and intracorporeal robotic mechanisms with the goal to minimize the number and length of incisions as well as to provide better triangulation in LESS cases.[52]

Central to the premise of single-site surgery is that it provides equivalent outcomes with improved cosmesis. Further studies should be focused on patient quality of life and satisfaction with cosmesis to determine whether these goals are truly being reached. Further study is also necessary to elucidate any potential benefits with respect to pain and convalescence benefits that may be conferred.

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