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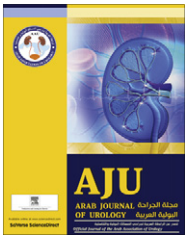

REVIEW

Laparoendoscopic single-site surgery in urology: Evaluation of complications

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KEYWORDS

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LESS;
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ABBREVIATIONS

LESS, laparoendoscopic single-site surgery; CL, conventional laparoscopy

Abstract ***Objective:*** To comprehensively review current reports on the complications of laparoendoscopic single-site surgery (LESS), introduced recently into urology as an option for treating various urological pathologies.

Methods: We reviewed previous reports to August 2011 using Medline, focusing on LESS in urology, with special interest in the complications, evaluating those during and after surgery, as well as conversions to reduced-port laparoscopy, conventional laparoscopy and open surgery.

Results: There are increasing reports of LESS in urology, with expanding indications. Complication rates both during and after surgery are low and related mostly to the technical difficulty and dexterity with the currently available instruments. Overall, intraoperative complications were reported by 11 published studies, while postoperative complications were reported by 15. Although the overall conversion rates to open surgery and conventional laparoscopy were low, the incidence of reduced-port laparoscopy was significantly higher.

Conclusions: Although there are expanding indications for LESS in urology, the risk of complications is low. This might be related to the fact that LESS is still restricted to experienced laparoscopic surgeons, and to the criteria for selecting patients.

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Introduction

Although the first studies of single-incision laparoscopy were reported by general surgeons in 1998 [1] and 1999 [2], urological surgeons pioneered the surgical innovations and technological advances in the field of single-port laparoscopy when Rane et al. [3] reported the first laparoendoscopic single-site surgery (LESS) nephrectomy in 2007. Conceptually, the aim of single-port laparoscopic surgery is to replace conventional multi-port laparoscopy and thus have smaller incisions, less blood loss, decreased incidence of port-site related complications, less postoperative pain and analgesic requirement, shorter hospital stay, rapid recoverability of the patient and, of course, better cosmesis [3,4]. Currently, LESS has been described as an alternative to conventional laparoscopy for treating almost all urological pathologies [5–7]. LESS encompasses procedures using one working port placed anywhere along the patient's trunk [4]. There are two options for configuring the instruments; either using conventional ports placed side-by-side in the same skin incision; or via a multichannel port specifically designed for that purpose [8].

Although current evidence suggests that LESS is comparable if not superior to conventional laparoscopy (CL) in terms of peri- and postoperative outcomes, there is a lack of reporting or description of the complications of LESS [7,9–16]. In this review we report the currently reported complications of LESS.

Methods

To August 2011 we searched the Medline database through PubMed, including all articles published in English and specifically focusing on the complications of LESS. The terms used in the search included: 'laparoscopic single-site surgery', 'LESS', 'urology', and 'complications'. Only complications of LESS in urology reports were reviewed. We evaluated detailed analyses of specific complications of LESS and their relation to both timing (intra- or postoperative) and LESS-specific instrumentation and techniques (access, instruments used and its effect on dexterity and triangulation).

For grading the severity of the complications of LESS, most of those reviewed were assigned according to the Clavien-Dindo classification, and we subsequently classified complications in the same way [17]. Although conversion cannot be regarded as a complication in itself, it was included in the evaluation of the results, as it represents an important component of the potential risks vs. benefits of any minimally invasive procedure, as it can affect the postoperative course [18]. An inherent risk of conversion, either to open surgery or to standard or reduced-port laparoscopy, must be considered in every LESS procedure, and consequently conversion specifically highlighted in this review.

Results

The review showed that there are increasing reports of the use of LESS in urology, with expanding indications. The published series for LESS can be divided into two categories depending on the number of cases included. Being a novel technique, most of the early publications were case reports that included only a few patients. As the procedure progressively became established in several experienced centres, the numbers of cases increased and multi-institutional studies have now been published. Consequently, clearer conclusions about the complications of the procedure could be drawn. Table 1 (small case series) and Table 2 (large case series) [19–33] summarise the number of patients, procedures, the rate of encountered complications (both during and after surgery), and conversions, whether into CL, reduced-port laparoscopy or open surgery, that have been reported in various LESS studies. Overall, intraoperative complications were reported only by 11 published studies and these varied between Clavien grade II and IIIb, while postoperative complications were reported by 15 studies and these ranged between Clavien grade I and V. Reduced port-laparoscopy was reported by eight different studies, while conversion to CL and open surgery was reported by six different studies for both.

Discussion

LESS procedures in urology have been progressively popularised worldwide over the past 4 years. However, any new surgical technique should be carefully and objectively evaluated for the risk of complications and conversions. Although complications have been reported within many reports of LESS, only a few studies have specifically addressed the issue of complications with LESS.

In several small series of LESS, although most of these reports were of complex procedures, no complications were reported, e.g. in five patients with LESS repair of vesicovaginal fistula, six cases of ureteric reconstruction, 13 donor nephrectomies, another six donor nephrectomies through a 5-cm Pfannenstiel incision, or 11 nephrectomies [7,10,19,20,34]. However, selection bias probably had a major role in there being no complications in some of these reports. Another series that included five LESS nephrectomies reported postoperative complications in two patients, i.e. port-site bruising in one and fever in another [21]. Similarly, Han et al. [22] recently published 14 LESS simple nephrectomies, with two reported complications (pyrexia in one patient and ileus in another). Stolzenburg et al. [23] recently reported their LESS radical nephrectomy technique in a series of 10 non-obese patients. They encountered bleeding in one patient, who needed a blood transfusion. Moreover, they reported limitations in the intraoperative

Table 1 The complications and conversion in small case series.

Study	Total *n* patients	Procedures, *n*	Intra-operative	Complications, *n* (Clavien grade)		Comments
				Postoperative	Conversions, *n*	
[7]	5	Repair VVF	None	None	RPL (4) (extra 5-mm port used)	–
[19]	13	DN	None	None	RPL (11) (extra 2–5 mm ports used)	–
[20]	6	DN	None	None	None	Done through 5 cm Pfannenstiel incision
[10]	11	N (45% SN, 55% RN)	None	None	None	Comparative study with CL arm
[21]	5	SN	None	Pyrexia, 1 (I) Port-site bruising, 1 (I)	None	–
[22]	14	SN	None	Pyrexia, 1 (I) Ileus, 1 (I)	None	–
[23]	10	RN	BRT 1 (II)	None	None	–
[24]	5	PN	None	Pseudoaneurysm Required AE, 1 (IIIa); PE, 1 (II)	RPL (1) (5 mm port added)	–
[25]	7	PN	BRT, 1 (II)	PSM, 1 (III)	CL (1) (due to bleeding)	2 cases were RA LESS
[12]	21	RN (11) PN (2) RCA (1) Renal biopsies (2) RCD (1) SN (4)	None	PSD, 1 (IIIb) Small bowel Obstruction, 1 (IIIb)	None	–
[26]	19	Adrenalectomy	None	Angina, 1 (II)	None	Comparative study with CL arm
[14]	28	Pyeloplasty	None	Haematuria, 1 (I) Urine leak resolved spontaneously, 1 (I) Retroperitoneal haematoma, 1 (II) Urine leak required nephrostomy tube, 2 (IIIa) Symptomatic hydronephrosis required nephrostomy tube, 2 (IIIa)	RPL (21)*	Multi-institutional study
[27]	4	RP	BRT, 1 (II)	PSM, 2 (III) Recto-urethral fistula, 1 (IIIa)	None	–
[28]	34	Simple transvesical Prostatectomy	BRT, 5 (II) Bowel	Epididymo-Orchitis, 1 (I) Injury, 1 (IIIb)	Open (4) Death, 1 (V)	–

* Temporarily placed a midaxillary 3- or 5-mm port to facilitate intracorporeal suturing. VVF, vesicovaginal fistula; BRT, bleeding requiring transfusion; (R)(S)(P)(D)N, (radical) (simple) (partial) (donor) nephrectomy; RPL, reduced port laparoscopy; AE, angioembolisation; PSD, port-site dehiscence; PSM, positive surgical margin; RP, radical prostatectomy; RCA, renal cryoablation; RCD, renal cyst decortication; PE, pulmonary embolism; RA, robot-assisted.

instrument ergonomics, and a requirement for ambidexterity of the surgeon.

Laparoscopic partial nephrectomy represents a technically demanding procedure, as it requires complete tumour excision, pelvicalyceal repairing, and renal parenchymal suturing within a reasonable warm ischaemia time. Nevertheless, the application of LESS has been extended to such a challenging procedure with carefully selected cases. A series of five partial nephrectomies resulted in one postoperative pseudo-aneurysm which required angio-embolisation, and a pulmonary embolism in the same patient [24]. Kaouk et al. [25] reported results on seven partial nephrectomy cases (two of which were robotically assisted). Bleeding requiring transfusion was noted in one patient and conversion to CL was required in another. The same authors reported the first series of single-port kidney cryotherapy [35]. The procedure was performed transperitoneally in two patients with anterior tumours, and retroperitoneoscopically in the other four patients with posterior tumours. Cryotherapy was feasible, with no reported complications.

The Johns Hopkins' experience paralleled these reports, in 21 LESS kidney procedures that were performed by the same surgeon [12]. Interestingly, there were no intraoperative complications or conversions to CL. One patient developed severe postoperative

Table 2 The complications and conversion in large case series.

Study	Total *n* patients	Procedures, *n*	Complications, *n* (Clavien grade)		Conversions, *n*	Comments
			Intraoperative	Postoperative		
[13]	125	**Non-reconstructive (77)** SN (37) DN (18) RCA (12) RN (5) Renal cyst ablation (2) NU (2) Adrenalectomy (1) **Reconstructive (48)** Pyeloplasty (35) PN (8) Ileal ureter Interposition (3) Ureteroneocystostomy (2)	Duodenal injury, 1 (IIIb)	Fever, 1 (I) Port-site haematoma, 1 (I) DVT, 1 (II) Corneal abrasion, 1 (II) Anti-emetic dyskinesia, 1 (I) Urinary obstruction, 3 (1 stented, resolved (IIIa)) UTI, 2 (II) Urine leak, 2 (IIIa) Haematuria, 1 (I) Upper extremity neuropraxia, 1 (I) Haemorrhage, 3 (2 required AE) (IIIa) 1 infected haematoma (IIIa) Urine leak, 1 (IIIa)	CL (7)	MIS
[16]	192	RN (49) Living DN (27) PN (24) Pyeloplasty (22) SN (21) Cyst marsupialization (16) RCS (9) Adrenalectomy (6) Renal biopsy (6) NU (6) UL (4) Nephropexy (2)	BRT, 3 (II) Constant CO_2 leak, 1 (NA)	Small incisional hernia, 1 (I) Ileus, 1 (I) Flank pain, 2 (I) Urinary leak after UL, 1 (II) UTI, 1 (II) Acute gastritis, 2 (II) Postop anaemia, 18 (II) Urinary fistula stented, 1 (IIIa) Bleeding + sepsis Needed AE, 1 (IIIa) Retained sponge, 1 (IIIb) Incisional hernia required surgical repair, 1 (IIIb) Cerebral stroke, 1 (IV) Contralateral atelectasis, 1 (II)	RPL (77) CL (11) Open (4)	MIS
[29]	100	**Renal procedures (74)** RCA (8) PN (15) Renal metastectomy (1) Renal biopsy (1) SN (7), RN (6), RCD (2) NU (7), DN (19) Dismembered pyeloplasty (8) **Pelvic procedures (26)** Varicocelectomy (3), RP (6) Radical cystectomy (3) Sacral colpopexy (13) Ureteric reimplantation (1)	BRT, 7 (II)	UTI, 1 (II) DVT, 1 (II) RUF, 1 (IIIa) Pseudoaneurysm Required AE, 1 (IIIa)		CL (6)
[30]	100	SN (14), RN (3) DN (17), NU (2) PN (6) Pyeloplasty (17) Transvesical RP (32) Renal cyst excision (1) Ureteric implantation (2) BRT, 1 (II) Ileal ureter (3) Transvesical mesh sling removal (1) Adrenalectomy (1) Hysterectomy (1)	Bowel injury Exploration, 1 (IIIb) BRT, 4 (II) Bleeding + exploration, 1 (IIIb)	Corneal abrasion, 1 (II) UTI, 1 (II) AED, 1(I) Bleeding + AE,1 (IIIa) Anastomotic leak requiring Nephrostomy drainage, 1 (IIIa) Death, 1 (V)	RPL (3) (added one 5-mm) CL (3) Open (4)	2 centres 22 LESS Pyeloplasties 3 with RA 1 simple RP with RA

(*continued on next page*)

Table 2 (*continued*)

Study	Total *n* patients	Procedures, *n*	Complications, *n* (Clavien grade)		Conversions, *n*	Comments
			Intraoperative	Postoperative		
[31]	50	**Conventional LESS (34)**				
		RN (8)	Bowel serosal tears, 2 (IIIb)	None	Open (1)	
		SN (8)				
		RCD (8)	Diaphragm partial tearing, 1 (IIIb)			
		NU (3), PN (2)				
		Adrenalectomy (2)				
		Partial cystectomy (1)				
		Ureterectomy (1)				
		Ureterolithotomy (1)				
		Robotic LESS (16)				
		PN (11), NU (3), RN (1)				
		SN (1)				
[32]	171	**Conventional LESS (98)**				
		RN (24), SN (17)	Diaphragmatic	Wound	RPL (8)	Most RA LESS used Additional hybrid port except for SN and RN
		RCD (22), NU (8)	Injury, 2 (IIIb)	Dehiscence, 3 (I)	Open (7)	
		PN (3)	Bowel injury, 2 (IIIb)	Ileus, 1 (I)		
		Adrenalectomy (2)	IVC injury, 1 (IIIb)	ARF, 1 (I)		
		Partial cystectomy (3)	Renal vein injury, 1 (IIIb)	BRT, 1 (II)		
		Ureterolithotomy (10)	Ureteric injury, 1 (IIIb)			
		Pyeloplasty (4)		RA treated by antibiotics, 1 (II)		
		Urachal mass excision (1)		RA needed drainage, 1 (IIIa)		
		Orchidectomy (1)		Ureteric stent migration, 1 (IIIa)		
		Seminal vesiculectomy (1)				
		Retroperitoneal mass excision (1)				
		RA LESS (73)				
		RN (2), SN (1), NU (12)				
		PN (56), Adrenalectomy (2)				
[33]	1076	Pyeloplasty (89)	Vascular injury, 19	36 (I)	+ one 2–3 mm	MIS (18 institutes)
		SN (130), DN (51)	IVC, 2	41 (II	instruments (82)	
		RN (172)	Renal vein, 2	14 (IIIa)	RPL (170)	No mention of type of postop complications.
		Simple RP (42)	Adrenal vein, 3	7 (IIIb)	CL (43)	13% of included cases were RA LESS
		PN (127), NU (39)	Portal vein, 1	5 (IVa)	Open (11)	
		Sacrocolpopexy (13)	Minor serosal tears, 5			
		RCD (115), RP (25) RC (6)	Splenic injury, 2 (minor, 1, major, 1)			
		Adrenalectomy (55)	Diaphragmatic injury, 2			
		Varicocelectomy (44)	Others, 7; bleeding, transvesical enucleation of prostate, 3			
		Ureterolithotomy (51)	Minor liver injury, 1			
		Others (43)	Rectal injury, 1			
			Ureteric injury, 1			
			Pleural injury, 1			

BRT, bleeding requiring transfusion; (R)(S)(P)(D)N, (radical) (simple) (partial) (donor) nephrectomy; RPL, reduced port laparoscopy; AE, angioembolisation; DVT, deep vein thrombosis; IVC, inferior vena cava; RCA, renal cryoablation; DVT, deep vein thrombosis; RCD, renal cyst decortication; NU, nephroureterectomy; RA, robot-assisted; MIS, multi-institutional study; RA, retroperitoneal abcess.

abdominal distension and subsequently had a dehiscence of his umbilical extraction site, requiring operative reclosure. Notably, the patient had multiple comorbidities and was on chronic steroid therapy. The other complication in their series was a postoperative small bowel obstruction which occurred in a patient who had a simple nephrectomy and presented with recurring abdominal pain.

Two case series have specifically evaluated LESS for upper tract procedures. Irwin et al. [13] reported 125 patients in a multi-institutional study. The procedures included 77 that were not reconstructive and 48 that were. Conversion to CL was necessary in seven patients (5.6%), requiring the addition of 2–5 ports. Reasons for conversion included facilitating dissection in three, facilitating reconstruction in three, and the control of bleeding in one. Three of the seven patients who required conversion to CL developed postoperative complications (Clavien grade II in two, and IIIa in one). All attempted LESS cases were completed with no need for open conversion. Complications occurred in 19 (15.2%) patients undergoing LESS surgery. On correlating these with the type of the procedure, complications were reported in 7.8% of non-reconstructive compared to 27.1% in reconstructive procedures. The authors concluded that LESS seems to be associated with higher complication rates than in mature laparoscopic series, but conversions occur infrequently, reflecting stringent patient selection.

The limitations of this study [13] include the inability to standardize the selection criteria for the LESS patient, instrumentation and surgical technique, and the lack of available complete data from a CL control group for comparison.

In a similarly designed study but with an added risk analysis, Greco et al. [16] reported 33 (17%) complications (30 early, two intermediate, and one late) in 192 upper-tract LESS procedures. The CL conversion rate was 6%. There were statistically significant associations between the occurrence of complications and age, American Society of Anesthesiology score, estimated blood loss, length of hospital stay and malignant disease at pathology. Thus, these authors concluded that surgeons approaching LESS should start with benign diseases in patients at low surgical risk, to minimise the likelihood of postoperative complications. There was no analysis of risk factors for conversions. Other smaller series reported complications in two patients (postoperative angina and contralateral atelectasis) of 19 patients who underwent LESS adrenalectomy [26].

In a study specifically designed to evaluate the complications of LESS pyeloplasty, seven of 28 patients (25%) had a total of eight complications [14]. Four patients required a nephrostomy tube (14%) soon after surgery, two for symptomatic obstruction despite the ureteric stent, and two for a urine leak. Another had urine leakage that resolved spontaneously after she went home with the surgical drain on place for 1 week. One patient (4%) developed a retroperitoneal haematoma and required a blood transfusion, and one had haematuria that prolonged the hospital stay by 2 days. Notably, these authors used CL needle drivers and temporarily placed a mid-axillary 3- or 5-mm port to facilitate intracorporeal suturing in 21 cases. However, the authors concluded that LESS pyeloplasty is still technically difficult, even for an experienced laparoscopic surgeon.

Evaluating lower-tract LESS procedures, Kaouk et al. [27] presented an initial feasibility study on LESS radical prostatectomy on four patients. Positive surgical margins were detected in two patients with extracapsular extension. At 2 months after surgery a recto-urethral fistula was diagnosed in one case. The challenges of the technique were mostly related to ergonomics and intracorporeal suturing, and to limitations in available instrumentation. Although LESS pelvic surgery has already been recognised as highly challenging, and this is strictly related to the peculiar unfavourable ergonomics of LESS, a successful LESS repair of vesicovaginal fistula was reported by our group, with no complications in five patients [7].

LESS has also been studied as a treatment option for benign prostatic pathologies. Desai et al. [28] published their experience in 34 patients who had a single-port transvesical enucleation of the prostate for large-volume BPH. Digital adenoma enucleation was used in 19 (55%) cases. There was one death from postoperative bleeding due to uncontrolled coagulopathy. Other major complications were one bowel injury, one epididymo-orchitis and five haemorrhages. Given these outcomes, together with technical challenges and the availability of other options for large prostate adenomas (i.e. holmium laser prostatectomy, photoselective vaporisation), the effect of LESS on the management options for BPH remains poorly defined.

Increasing experience and the proven feasibility of LESS have allowed for the reporting of larger LESS series, from which more information can be gained. The Cleveland Clinic group reported their experience of LESS in the first 100 cases [29]. This encompassed 74 LESS renal procedures, and 26 LESS pelvic procedures. Six patients required conversion to CL, but none to open surgery. The overall complication rate was 11%. Complications included seven cases of blood loss requiring transfusion, one postoperative UTI, and one recto-urethral fistula after radical prostatectomy. The authors comment that intraoperative bleeding can be more challenging with LESS, and that the introduction of additional ports might be a necessity in certain situations. This relatively low incidence of overall complications in this ‘initial experience’ series might be attributed to the careful selection of cases, with an inherent selection bias.

Similarly, Desai et al. [30] reported their experience in 100 LESS cases. The addition of one or more ports was

needed in six cases, and conversion to open surgery was necessary in four, with an overall conversion rate of 10%. There was one death after a simple prostatectomy. The overall complication rate was 14%. Jeon et al. [31] reported their cumulative experience with 50 patients undergoing LESS, using a home-made single-port device. Of these patients, 34 had conventional LESS, while 16 had robotic-assisted LESS. There were four intraoperative complications, including two bowel serosal tears, partial tearing of the diaphragm, and conversion to open radical nephrectomy. One case of postoperative bleeding was managed by transfusion. Choi et al. [32] reported their series of 171 patients treated by LESS (98 conventional, and 73 robotic). There were intraoperative complications in seven cases (4.1%), and postoperative complications in nine (5.3%). Conversion to mini-incision open surgery was required in seven (4.1%) cases.

Recently, Kaouk et al. [33] published a worldwide multi-institutional analysis of 1076 LESS cases from 18 participating institutions. This report undoubtedly represents the most comprehensive description of the procedure and its complications to date. Among these cases, an additional port was collectively used in 23% of cases. In 34% of these, a 2- to 3-mm extra port was used, whereas in the remaining 66% of cases, an extra 5- to 12-mm additional port was required. The overall conversion rate was 20.8%, with 15.8% of cases converting to reduced-port laparoscopy, 4% to CL or robotic surgery, and 1% to open surgery. Reasons for conversion were difficult dissection (37% of converted cases), failure to progress (21%), bleeding (25%), difficult suturing (11%), difficult retraction (3%), and difficult access (3%). The intraoperative complication rate was 3.3%, and postoperative complications were encountered in 9.5% of cases, most being low grade according to the Clavien-Dindo system [13]. The overall transfusion rate was 6.1%. Although Martin et al. [36] established a list of 10 critical elements that should be included when reporting surgical complications, aiming to provide a more accurate and comprehensive picture of surgical morbidity and to allow reliable comparisons of the outcomes among different institutions, surgeons, or surgical techniques, it has been noted that this standardised reporting method remains underused in urological reports [37].

Conclusion

LESS is feasible and can be safely applied to a variety of urological procedures. Although LESS is an evolving technique that might have a challenging learning curve, the incidences of reported complications and conversion are relatively low, possibly due to careful selection criteria for cases. Moreover, application of this evolving technique is limited to highly experienced centres and well-trained surgeons with an extensive laparoscopic background.

Conflict of interest

The author has no conflict of interest to declare.

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