

# Evolution and simplified terminology of natural orifice transluminal endoscopic surgery (NOTES), laparoendoscopic single-site surgery (LESS), and mini-laparoscopy (ML)

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## Abstract

**Introduction** Natural orifice transluminal endoscopic surgery (NOTES) and laparoendoscopic single-site surgery (LESS) are the next steps in the evolution of laparoscopic surgery, promising reduced morbidity and improved cosmetic result. The inconsistent terminology initially used led

to confusion. Understanding the technical evolution, the current status and a unified and simplified terminology are key issues for further acceptance of both approaches.

**Objective** To present LESS and NOTES in its historical context and to clarify the associated terminology.

**Method** Extensive literature search took place using the PubMed. Several hundred publications in general surgery and urology regarding LESS are present including the expert opinion of members the European Society of Uro-technology (ESUT).

**Results** The increasing interest on NOTES and LESS is reflected by a raising number of publications during the last 4 years. The initial confusion with the terminology of single-incision surgery represented a significant issue for further evolution of the technique. Thus, consortiums of experts searched a universally acceptable name for single-incision surgery. They determined that ‘laparoendoscopic single-site surgery’ (LESS) was both scientifically accurate and colloquially appropriate, the term being also ratified by the NOTES working group (Endourological Society) and the ESUT. For additional use of instruments, the terms hybrid NOTES and hybrid LESS should be used. Any single use of miniaturized instruments for laparoscopy should be called mini-laparoscopy.

**Discussion** The evolution of LESS and most likely NOTES to a new standard of minimally invasive surgery could represent an evolutionary step even greater than the one performed by the establishment of laparoscopy over open surgery.

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## Introduction

The first laparoscopic nephrectomy performed by Clayman in 1991 led to a revolution in urological surgery [1]. The initially demonstrated advantages of minimally invasive surgery (i.e., laparoscopy) were later confirmed by numerous reports [2, 3], and laparoscopic surgery currently is the standard of care for renal ablative procedures [4, 5]. Partial nephrectomy and radical nephrectomy for large tumors are still indications that are under debate regarding the most appropriate technique: the laparoscopic, robot-assisted or open surgical approach. Nevertheless, rapidly evolving technologies will probably set an end to this debate. In fact, laparoscopic partial nephrectomy has been proven to have faster postoperative recovery [6] and comparable oncological and functional outcomes [7].

### Morbidity of laparoscopy

Constant surgical development of laparoscopic technique has provided the potential for even less invasive techniques than conventional laparoscopy. A significant advantage of laparoscopic over open surgery is the lack of large incisions and their related morbidity significantly reducing the access trauma. Nevertheless, laparoscopic approach still requires 3–5 incisions of 5–12 mm width for respective port placement. Thus, there is risk of bleeding, wound infection, organ damage, hernia formation, and compromised cosmetic result. Wound infection following an open surgical procedure occurs in up to 25 % of patients [8]. Despite the markedly decreased risk of wound infection with laparoscopic approaches, site infections still occur and have been reported in up to 5.8 % of laparoscopic urological surgeries [8]. In fact, a recent report reveals that the vast majority of those site infections (71.4 %) take place at the specimen extraction site. As a result, the reduced number of ports may contribute to lower infection rates [9].

Incisional hernias represent a well-known complication of both open and laparoscopic surgery. The risk for incision hernia is also directly related to the number and the dimension of the incisions, and the incidence of incisional hernias has been reported in up to 18 % of patients undergoing open abdominal surgeries [10] and in up to 3 % of those undergoing laparoscopic procedures [11].

Another concept introduced by minimally invasive surgery is the postoperative cosmetic outcome. Minimal scarring is increasingly demanded by most patients, and the development of “scarless” surgery is a promising concept.

## The concept of LESS and NOTES

Consequently, the next evolutionary step of laparoscopic surgery was to move toward the use of fewer trocars or even the use of natural orifices as access points that could conceal the scar of the incision. Moreover, recent evidence showed that the reduction in ports results in reduced operative morbidity [12–14].

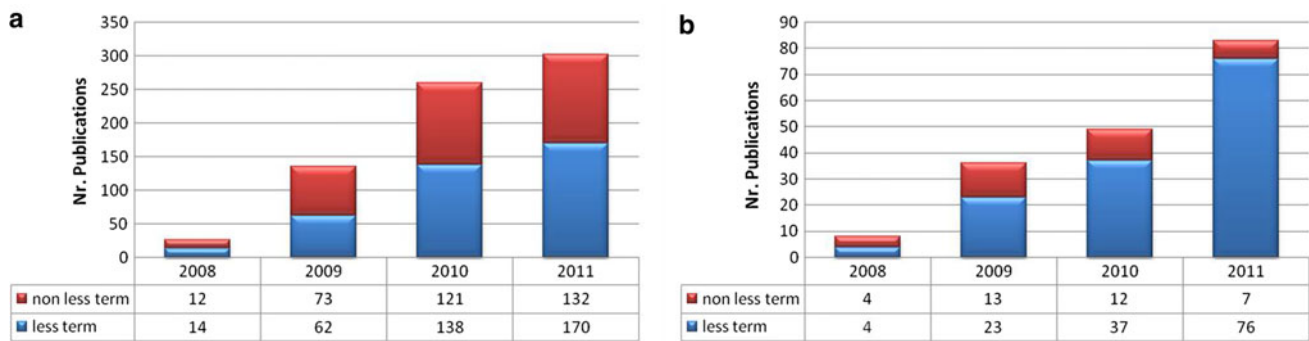
Such attempts have led to various techniques being developed which in turn have been presented with a multitude of terminologies (Table 1). *Laparoendoscopic single-site surgery (LESS)* and *natural orifice transluminal endoscopic surgery (NOTES)* are two new minimally invasive approaches that may represent the next generation of minimally invasive abdominal and retroperitoneal surgery. The terms NOTES and LESS are the ones proposed by an international panel of experts, the urologic NOTES working group in 2007 [15]. This review seeks to place LESS in its historical context and attempts to clarify and simplify the terminology associated with these two novel procedures.

### Literature search

Extensive literature search took place using PubMed. Several hundreds of publications in general surgery and urology regarding LESS are present (Fig. 1). There is an increasing interest on LESS which is reflected by the increasing number of publications in both medical specialties during the last 4 years. Figure 1 depicts the increasing interest on LESS in general surgery and urology. The presentation of the literature in the current review aims to present the evolution of the LESS and NOTES in conjunction with the development of a unified and simplified terminology.

**Table 1** Terms used to describe single-incision surgery

NOTES	Natural orifice transluminal endoscopic surgery
E-NOTES	Embryonic
NOTUS	Natural orifice transumbilical surgery
OPUS	One port umbilical surgery
SPA	Single-port access
SILS	Single-incision laparoscopic surgery
SSA	Single-site access
SAS	Single-access-site laparoscopic surgery
SPL	Single-port laparoscopy
SITUS	Single-incision triangulated umbilical surgery
TULA	Transumbilical laparoscopic assisted
TUES	Transumbilical endoscopic surgery
LESS	Laparoendoscopic single-site surgery



**Fig. 1** **a** Publications using the term less/other term in surgery, **b** Publications using the term less/other term in urology

## Results

### Experimental basis of NOTES in urology

The purpose of NOTES is to imply natural orifices of the body such as the mouth, anus, vagina, and urethra as an access point to the abdominal cavity. The first description of NOTES is accredited to Kalloo et al. [16] who demonstrated an experimental work on the feasibility of a peroral transgastric endoscopic approach to the peritoneal cavity with long-term survival in animals. In 2002, the first successful experimental application of NOTES in urological surgery was documented when six laparoscopic transvaginal nephrectomies in a porcine model were performed [17]. The technically challenging nature of the procedure was demonstrated by the fact that five of the six pigs required a separate transabdominal port for completion of the procedure. Factors like unfamiliar working angle, lack of mobility, instrument limitation, all contributed to prolonged operative times (210–360 min).

In fact, significant safety issues were raised by investigators using a transgastric approach. The deliberate perforation of an otherwise normal organ seems to be unreasonable and may be detrimental and eventually disastrous, whenever the closure of the access organ fails [18]. Consecutively, the transgastric as well as other approaches such as transurethral/transvesical or transrectal were used in experiments [19–22].

### Transvaginal NOTES and hybrid NOTES

The only NOTES approach being clinically feasible in urologic patients represents the transvaginal access [23, 24]. The transvaginal approach is related to practically “scarless” cosmetic since even large specimens can be extracted through the vagina without leaving any visible scar. In addition, the closure of the vaginal incision is considered to be related to low complication rates. Nevertheless, the performance of transvaginal NOTES is

associated with ergonomic and safety issues such as the unfamiliar working angle, longer distance to the upper urinary tract, and higher risk for bowel injury during the initial entrance to the abdominal cavity. These limitations can be overcome by the insertion of additional transabdominal access trocars and respective instruments, leading to the performance defined as *hybrid NOTES*. The latter approach is performed by the insertion of instruments and extraction of the specimen through a vaginal access while additional instruments are inserted through the umbilicus [25–27].

Several investigators have reported nephrectomy procedures with vaginal access with the use of various ports and instruments in small patient series [24]. Alcaraz was the first to report the performance of NOTES-assisted transvaginal nephrectomy in one patient with atrophic kidney and subsequently expanded their experience with 14 cases [26]. Laparoscopic trocars were inserted through the umbilicus, abdominal wall, and vagina. The specimen was extracted through the vagina. Transvaginal NOTES-assisted mini-laparoscopic nephrectomy was also performed by Porpiglia in a series of 5 patients. The authors used one 5-mm trocar at the umbilicus, two 3-mm trocars through the abdominal wall, and a bariatric 12-mm trocar through the vagina. Vaginal extraction of the specimen took place in all cases [25]. More recently, Alcaraz presented a series of 20 transvaginal NOTES-assisted living donor nephrectomies and compared the results to a previous series of 20 laparoscopic living donor nephrectomies. Warm ischemia time of the graft was significantly longer in the case of transvaginal approach, however, without compromising the function of the graft [27].

Nevertheless, the limited clinical experience with hybrid transvaginal NOTES is not adequate to draw solid conclusions regarding the advantages of the procedure. Any wide acceptance of the approach requires extensive clinical evaluation of the safety of the technique and specialized instruments [28]. Some issues have to be addressed, such as the effect of NOTES on sexual function, particularly in

younger (nulliparous) women. We should critically assess the rationale before taking the risk of an ergonomically inferior access.

### LESS and assisted LESS

The limitations of NOTES and the lack of significant clinical experience increased the interest in single-site laparoscopy, which is performed through the single abdominal or retroperitoneal incision. As a result, LESS has been proposed as the latest evolution of laparoscopic surgery.

#### *Pure LESS (=LESS)*

The concept of LESS using the umbilicus as access site pioneered by the gynecologists in the 1960 s and 1970 [29, 30], goes back to the operative resectoscope developed by Buess in the 1980 s [31]. Nevertheless, the technology of that time did not provide the background for the development of the approach. The first report concerning LESS was by Raman et al. [32] who performed a single umbilical incision nephrectomy in four pigs (eight renal units). The initial two LESS clinical urological cases (a simple nephrectomy and an ureterolithotomy) were reported by Rane as abstract at the World Congress of Endourology in 2007 [33]. Since these first reports, clinical experience on LESS has been significantly accumulated and most ablative and reconstructive procedures in urology are feasible by LESS approach. Careful patient selection, experienced surgeons, and improved instrumentation led into further clinical investigation into LESS [34].

Nevertheless, the most important factor for the performance of LESS remains the ergonomic problems associated with the in-line insertion of instruments through the same incision. These technical challenges such as the lack of instrument triangulation and instrument clashing are associated with a steep learning curve and render difficult tasks such as intracorporeal suturing, a demanding process even in the hands of experienced surgeons [28, 35]. The development of specialized instruments limited the above problems and contributed to the success of LESS in demonstrating comparable results to conventional laparoscopy.

Pioneering investigating groups has compared LESS nephrectomy, pyeloplasty, sacrocolpopexy, adrenalectomy, donor nephrectomy, and radical prostatectomy to the respective laparoscopic procedures [24]. The majority of the investigators do not conclude any significant advantage of LESS approach over conventional laparoscopy except for the improved cosmetic outcome. Only Jeong [36] revealed reduced postoperative pain in the case of LESS

adrenalectomy in comparison with its laparoscopic counterpart, and Canes et al. [37] demonstrated that single port may be associated with quicker convalescence when a series of LESS donor nephrectomies were compared to a retrospective series of laparoscopic donor nephrectomies.

#### *Hybrid LESS (ML- or NS-assisted LESS)*

The performance of LESS sometimes requires *the insertion of additional laparoscopic instruments* directly through the abdominal wall. These instruments facilitate the safe accomplishment of the procedure by providing tissue retraction. In fact, the pioneering investigators on LESS report the use of additional instruments that were frequently 5 mm in diameter, while the use of 3-mm instruments was also favored by some investigators [38, 39]. The use of these instruments takes place in case of necessity and facilitates tissue retraction such as liver retraction during right-side nephrectomy and difficult tasks like suturing during radical prostatectomy.

Based on the size of the instruments one may distinguish between mini-laparoscopic (ML)- and needlescopic (NS)-assisted LESS: Needlescopic-assisted LESS makes use of additional 2- to 3-mm needlescopic instruments. A multi-lumen port is inserted at the umbilicus, and LESS instruments are introduced through the port while the needlescopic instruments are inserted directly or via minitrocars through the abdominal wall to facilitate the procedure. Mini-laparoscopic LESS uses 3- to 5-mm instruments.

The most important advantage of *ML- or NS-assisted LESS* is that the approach provides instrument triangulation and the principal ergonomic limitation of LESS, the lack of instrument triangulation, is no more an issue. Moreover, the additional scars of the instruments are practically invisible and the use of these instruments shares the main purpose of LESS, which is the performance of efficient “scarless” surgery. Aron et al. [40] performed needlescopic-assisted LESS partial nephrectomy and used 3-mm instruments to replicate the conventional laparoscopic partial nephrectomy. Gill and Desai et al. performed needlescopic-assisted pyeloplasties, donor nephrectomies, and reconstructive procedures such as ureteroneocystostomy [41, 42]. More recently, Breda et al. reported their experience with laparoscopic donor nephrectomy performed with the use of needlescopic instruments. In fact, one 5-mm camera trocar was inserted at the umbilicus, and 3 needlescopic trocars were inserted on the lateral margin of the rectus muscle. The kidney was removed through a Pfannenstiel incision. Although the authors did not characterize the procedure as needlescopic-assisted LESS donor nephrectomy, the concept is the same [43].

### Robotic-assisted LESS

The challenging nature of LESS approach led to the use of the robotic platform (VeSPA, Da Vinci system, Intuitive, Sunnyvale, CA, USA) during the early steps of LESS. In fact, the first report dates back in 2009 when Kaouk et al. [44] performed the first robotic-assisted LESS procedures. The experience of the above investigating group expanded and included the performance of 20 cases of robot-assisted LESS radical prostatectomies [45]. It should be noted that all the procedures were performed through an umbilical multi-lumen port and 1–2 additional robotic ports one in each side of the multi-port. The experience accumulated by the use of the robotic system in single-port surgery has contributed to the development of specially designed for LESS instruments that are currently under evaluation [46, 47]. Considering the above, robotic assistance for the performance of LESS seems to be a promising direction for the evolution of the LESS approach. Interestingly, this approach (VeSPA) requires more laparoscopic than robotic expertise since the instruments provide only four degrees of freedom (DOF) [47].

### Flexible laparoscopy/LESS platforms

Apart from robotic-assisted LESS, recently, a conceptual solution to improve the ergonomics of LESS has been introduced by the SPIDER Surgical System (TransEnterix, Morrisville, NC, USA), which uses steerable tube technology to regain triangulation [28]. Haber recently presented first experimental and clinical experiences with this device which has FDA approval for LESS cholecystectomy [48].

### Mini-laparoscopy

Parallel to the development of LESS and NOTES, the use of miniaturized instruments and endoscopes has evolved, by significant improvements in video technology (Table 2), such as HD [12–14, 49]. As mentioned before, this was

**Table 2** Terms used to describe mini-laparoscopic approaches

NS	Needlescopy: 2 mm rigid instruments and telescope
ML	Mini-laparoscopy: 3- to 5-mm rigid instruments and telescopes
mL	Microlaparoscopy: flexible 2-mm endoscopes
ML hybrid	Use of ML together with a larger port (10 mm)
ML assistance	Use of ML together with LESS or NOTES (hybrid)
SLIP	Small strategic laparoscopic incision placement
SMART	Small-access retroperitoneoscopic technique

based on earlier studies by Soble and Gill [12]. Recently, Porpiglia has used 3-mm instruments and telescope to perform a mini-laparoscopic (ML) pyeloplasty [14]. Pini et al. [13] presented a matched-pair analysis comparing functional and cosmetic outcome of SMART (small-access retroperitoneoscopic technique) pyeloplasty with conventional retroperitoneoscopy. Using a patient and observer score systems (POSAS) developed for traumatic surgery, they found significant advantages for the SMART technique without deterioration in functional outcome. For reconstructive procedures, mini-laparoscopy may represent a technique even superior to LESS, but in case of ablative surgery, the additional use of miniaturized instruments seems to be reasonable (=hybrid LESS).

### Terminology in NOTES and LESS

The presentation of literature shows that NOTES and LESS are characterized by a series of inhomogeneous technical innovations, resulting in a number of different descriptions for each approach. Thus, significant confusion in terminology was present since the first steps of single-site surgery and was attributed to the already complicated nature of the approaches. Table 1 presents several terms used in the past to describe LESS and NOTES. It should be noted that the constantly evolving field of single-port surgery gave birth to terms like NOTES, E-NOTES (embryonic NOTES), OPUS (one port umbilical surgery), SILS (single-incision laparoscopic surgery), SPAS (single-port access surgery) which in the past were competing for the future of laparoscopic urology [50].

### Nomenclature of NOTES

In order to simplify the terminology and to further clarify the nomenclature as well as to discuss the emerging role of NOTES in urology, a group of experts of the Endourological Society formed the Urology Working Group on NOTES in 2007 [51]. One of the purposes of the above group was the definition of nomenclature of urologic NOTES. Table 3 presents the definition of NOTES as presented by the above group. It should be noted that NOTES was divided into *pure NOTES* (access through one natural orifice), *combined NOTES* (access through two natural orifices), and *hybrid NOTES* (access through the natural orifice and transabdominal access). It is important to note that the working group concluded that the new more minimally invasive techniques (including single-incision techniques) must match or exceed the efficacy and safety of other accepted minimally invasive techniques for the emerging approaches to be justified.

**Table 3** Proposed simplified nomenclature for NOTES and LESS

Techniques	Modifications	Comments
NOTES	Pure NOTES: no additional ports	Pure NOTES = NOTES
	Combined NOTES: using two different orifices	Only experimentally for urologic indications
	Hybrid NOTES: additional transabdominal ports	In Urology mostly used in combination with transvaginal access
LESS	Pure LESS: no additional ports	In urology mostly used transumbilical access
	Hybrid LESS: additional transabdominal ports	(uLESS = LESS = pure LESS)
	Robotic LESS: use of VeSpA-System	With ML or NS assistance

### Nomenclature of LESS

In the case of LESS, an international consortium of experts in minimally invasive surgery (the Laparoendoscopic Single-Site Surgery Consortium for Assessment and Research–LESSCAR) met in 2008 with the goal of standardizing the terminology for academic communications [52]. Review of the literature at that time by this group identified more than 10 frequently used terms to describe surgery through a single incision. The conclusion of the consortium was to use the term “LESS” surgery in describing all procedures performed in a minimally invasive manner through a single incision. Furthermore, it was suggested that the term “U-LESS” be used to describe single-site surgery performed through the umbilicus. These terms aim to helping research efforts by providing a universal language for these techniques. This in turn allows search engines to be become more efficient regarding the developing literature. Furthermore, a standardized terminology promotes a more rapid dissemination of the results, knowledge, and ideas of clinical trials.

The *European Society of Urotechnology (ESUT)* similarly formed a working group dedicated to LESS and NOTES making new recommendations for the future of LESS and NOTES [53]. They underlined the progress in the field of single-site surgery based on the definition of nomenclature and the goals set by the previous groups. Encouraging is the fact that as the role of single-incision laparoscopic surgery continues to expand, consensus on the most appropriate name for the approach has currently been achieved at least in urology. New terms have, however, been introduced with the further evolution of LESS both in general surgery and in urology [54, 55].

Nevertheless, it should be noted that the fields of LESS and NOTES have already divided into different

subcategories which describe the assisting equipment or access used for the successful accomplishment of LESS (Table 3). In the current review, we presented these subcategories and showed that the intraoperative difficulties of LESS are overcome with the use of assisting equipments such as the robotic platform and needlescopic instruments (*hybrid LESS*) without compromising the concept of “scarless” surgery which is the major advantage of LESS. In course of time, we shall experience the evolution of LESS and most likely NOTES to a new standard of minimally invasive surgery, which would probably represent an evolutionary step even greater than the one performed by establishment of laparoscopy over open surgery.

### Discussion

Although LESS and NOTES are perceived as an important development of classic laparoscopy, this is not an entirely new idea. In fact, NOTES has been performed by endourologists as retrograde intrarenal surgery (RIRS) since a long time, and LESS is the development of an old technique [31]. The initial confusion with the terms used for the description of *single-incision surgery* represented a significant issue for the further evolution of the technique. Thus, consortiums of experts determined universally acceptable name for single-incision surgery. The consortiums determined that ‘laparoendoscopic single-site surgery’ (LESS) was both scientifically accurate and colloquially appropriate, and therefore, the term was also ratified by the NOTES working group of the Endourological Society and will be adapted as the future standard for the reference. For transumbilical single-incision surgery, the term U-LESS can be used, but since LESS is mainly performed via the umbilicus, most authors just use the term “LESS”. In conclusion, ESUT also recommends to use only LESS (Table 3).

Since mini-laparoscopic (needlescopic) approaches using 3- to 5-mm instruments have also evolved as techniques to minimize the access trauma of laparoscopy, the combination LESS and NOTES with these approaches resulted in the term “hybrid LESS” and “hybrid NOTES” significantly improving the ergonomics. Hybrid techniques are designed to combine the advantages of both techniques particularly in case of ablative procedures, where the LESS incision can be used for organ removal.

Thus, a question is raised regarding the use of additional needlescopic instruments during the performance of LESS. Several investigators consider the use of these instruments as a method to overcome intra-operative difficulties and employ them when it is deemed necessary (*hybrid LESS*), while others consider the use of 3-mm instruments as routine equipment for the performance of LESS. We prefer

the term hybrid LESS for *any use of additional instruments* regardless their size.

Nevertheless, new terms are expected to be introduced as LESS evolves. In fact, the complexity of the accesses used during LESS has already divided the field in different subcategories, which describe the assisting equipment or access used for the successful accomplishment of LESS. In course of time, we shall experience the evolution of LESS and most likely NOTES to a new standard of minimally invasive surgery, which would probably represent an evolutionary step even greater than the one performed by establishment of laparoscopy over open surgery.

**Conflict of interest** The authors declare that they have no conflict of interest.

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