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Laparo-Endoscopic Single-Site (LESS) Visceral Surgery

Current status and future evolution

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ABSTRACT

Background: Laparo-Endoscopic Single Site (LESS) surgery, also known as single port access (SPA) or single incision laparoscopic surgery (SILS), is rapidly emerging as an attempt to improve cosmetic results, reduce parietal morbidity and speed up recovery from minimally invasive surgery. As Laparo-Endoscopic Single Site (LESS) surgery is poised to quickly move forward, an understanding of its evolution, current status and expected future development is timely.

Objective: To review the history, current status and future development of Laparo-Endoscopic Single Site (LESS) surgery, including a brief review of our own experiences.

Data Sources: This review is based on published literature obtained by means of a PubMed search.

Data Synthesis: Among 81 papers, disregarding reviews or opinion leader manuscripts relating to the surgical technique of Laparo-Endoscopic Single Site surgery, 52 related to visceral, 20 to urologic, and 9 to gynecological procedures. Technical improvements over the last years have allowed to perform multiple and advanced procedures through Laparo-Endoscopic Single Site surgery. However, instrumentation refinements are needed to improve the feasibility and operative time of single port access procedures compared to standard laparoscopy. The cosmetic advantages of Laparo-Endoscopic Single Site surgery compared to standard laparoscopy or open surgery are clear. Data regarding the safety and potential advantages of Laparo-Endoscopic Single Site surgery are still missing.

Conclusion: Laparo-Endoscopic Single Site (LESS) surgery has made its initial forays into clinical minimally invasive surgery. Ongoing refinements in technique and instrumentation will expand its future role and open the era of scarless abdominal surgery.

INTRODUCTION

Laparoscopy has become the gold standard approach for various visceral surgeries. The reason for this trend, beside the clinically demonstrated advantage of laparoscopy, is the patients’ demand for “scarless” surgery. This may prompt us to consider the importance of body image trauma associated with surgical procedures and look for “scarless” surgical procedures.

These facts and the patients’ demand are the basis of the development of the NOTES (Natural Orifice Translumenal Endoscopic Surgery) approach. The umbilicus is considered by some as a natural orifice, or embryological scar, thus Laparo-Endoscopic Single Site (LESS) surgery could represent another scarless or at least invisible scar approach. The interest generated by LESS surgery is sustained by the fact that this technique offers cosmetic advantages but can be performed with currently clinically available instrumentation. It has recently been recognized in a NOTES consensus paper that whereas NOTES is still evolving predominantly in the lab, LESS surgery has already being clinically implemented.

RESULTS

Visceral single port access laparoscopic surgeries

Appendectomy

The first series of single port access appendectomies was reported in 1992 by Pelosi MA et al. This technique used a working channel laparoscope. The appendix was grasped and delivered through the umbilical incision, and the appendectomy was performed extracorporeally. Some reports of one-trocar assisted appendectomy in pediatric patients have shown interesting results in the nineties, driving the spread of this technique. D’Alessio A et al reported a larger series using this approach for appendectomy in pediatric patients in 2001, which is now referred to as transumbilical laparoscopic-assisted appendectomy (TULAA). In this series 140 patients underwent TULAA, with a conversion rate of 19% to standard laparoscopic approach and 4% to open approach. Mean operative time was 35 minutes and recovery after TULAA was faster than for standard laparoscopy. Recent reports have confirmed these results. However, while TULAA may be easily feasible in pediatric patients, it is less favorable in adult patients where umbilical exposition of the appendix basis may be difficult. Moreover, the rate of infectious complications on the umbilical wound of the TULAA technique is not negligible due to exposition of the contaminated appendix with the wound. For this purpose different techniques of transumbilical single port access appendectomy have been developed to conduct completely intraperitoneal appendectomies. Recently, Palanivelu C et al reported transumbilical endoscopic appendectomy using a flexible endoscope.

Cholecystectomy

The first transumbilical single incision cholecystectomies were reported in 1997 by Navarra et al. Navarra et al used two trocars in a single umbilical incision (2.5cm) and transparietal suture for gallbladder exposition. No conversions and complications were reported beside one case of umbilical wound infection. In 1998, Donini A et al reported a series of 95 patients in which they achieved in 64 cases successful cholecystectomy using a similar technique to Navarra G et al. In 1999, two series reported similar experiences with single incision laparoscopic cholecystectomy using the same approach.

In 2008, a renaissance in LESS cholecystectomy developed in the light of the recent development of natural orifice transluminal endoscopic surgery (NOTES). This renaissance of LESS cholecystectomy was probably driven by the report of transvaginal hybrid NOTES cholecystectomies, which were all performed with an additional transparietal port for exposition. Cuesta MA et al reported a series of so-called “invisible cholecystectomies”. The large Drexel University was present this year at the SAGES meeting, reporting on more than 100 single port access cholecystectomies with excellent results. Since this report, multiple reports of single port access or single...
incision laparoscopic cholecystectomy have been published.\textsuperscript{39-47} All of them have confirmed the feasibility of this technique and its relative safety (with the reserve of the small population studied).

**Abdominal wall hernia repair**

Only two reports of single port access laparoscopic repair of abdominal wall hernias have been published in 2008.\textsuperscript{48, 49}

**Colectomies**

The first single port access laparoscopic surgery in colorectal surgery was recently described.\textsuperscript{6, 15} Transumbilical SPA radical right colectomy was performed using working channel laparoscope. Recently the Cleveland group reported a single port laparoscopic right colectomy using a multiport which facilitated exposition and dissection.\textsuperscript{50} First experiences with transumbilical SPA left colectomy and sigmoidectomy have been reported by the Geneva group.\textsuperscript{51} However, these advanced surgical procedures need instrumentation development to facilitate these complex surgeries before their routine clinical application.

**Gastrointestinal surgeries**

Single incision laparoscopic sleeve gastrectomies have been described simultaneously in 2008 by two groups.\textsuperscript{52, 53} Saber AA et al reported a series of 7 transumbilical single incision laparoscopic sleeve gastrectomies without morbidity.\textsuperscript{53} They conclude that transumbilical single incision laparoscopic sleeve gastrectomy is safe, reproducible and may be associated with shorter recovery and better cosmetic results.\textsuperscript{53}

Recently, three groups have reported single access laparoscopic gastrostomy placements in children without complication.\textsuperscript{54-56}

**Pancreatic and splenic surgeries**

Single port access treatment of infected pancreatic necrosis during bouts of acute pancreatitis has been described through single flank incision.\textsuperscript{52, 57} Recently these approaches have been reviewed and transperitoneal and retroperitoneal single port access endoscopic pancreatic necrosectomy have been reported.\textsuperscript{52} Pancreatic tail resection through single port access laparoscopy has been described by Bucher P et al in 2008 after recovery from acute pancreatitis with excluded pancreatic tail.\textsuperscript{52} Splenic surgery (splenectomy) has been briefly touched on during the SA-GES meeting in 2008 by the Drexel University group, which used a single transumbilical incision laparoscopic approach.\textsuperscript{28}

**Other visceral surgeries**

Zhu JF et al reported their experience with various forms of transumbilical single port surgery, called transumbilical endoscopic surgery, in 40 cases.\textsuperscript{58} Liver cyst fenestration (3), bleeding ascites treatment (1), appendectomy for chronic right iliac fossa pain (10), cholecystectomy (26) were presented without postoperative related morbidity.\textsuperscript{58} Blessing et al elucidated their single-trocar technique for placement of a peritoneal dialysis catheter in 2005.\textsuperscript{59}

**University Hospital Geneva experience**

A program of laparo-endoscopic single site surgery was started in 2007 in our center. More than 100 cases have been completed, including appendectomies, cholecystectomies, umbilical and ventral hernia repair (transperitoneal approach), incisional hernia repair (transperitoneal approach), right and left colectomies, gastric surgeries, and some additional surgeries. The program was started using a working channel endoscope with exposition achieved using transparietal stitches as described by Navarra et al in the nineties. With the recent technical advance, the use of curved or articulated instruments and multiports has enabled us to improve the feasibility of laparo-endoscopic single site surgery.

**DISCUSSION**

**Cosmesis and surgery**

Patients favour laparoscopic surgery due to lower post-operative pain, faster recovery and earlier resuming of normal activity.\textsuperscript{1, 2, 60-64} However, the main reasons reported are better cosmetic results and lower body image trauma compared to open surgery.\textsuperscript{6, 26, 34, 62, 65} Recent surveys have shown that patients would prefer scarless surgery through a NOTES approach, even if this approach carried a slight increase in operative risk.\textsuperscript{67, 68} This should prompt us to consider the importance of body image trauma associated with surgical procedure and look for “scarless” surgical procedures, while keeping the patients’ safety as a primary rule.\textsuperscript{65, 66, 68}

**SPA versus standard laparoscopy**

As laparoscopy is favoured by patients for cosmetic and post-operative comfort, LESS surgery is advantageous as it results in an “invisible umbilical scar”.\textsuperscript{6, 7, 10, 11, 14, 26, 47, 71, 76, 77} Parietal trauma and possibly post-operative pain will be lower with LESS surgery as only one transparietal port is used.\textsuperscript{11, 14, 17, 14, 71-74} SPA may reduce the risk of parietal complications such as port placement related hemorrhages or incisional hernia.\textsuperscript{10, 14, 51, 72, 75-77}

LESS may offer those advantages compared to standard laparoscopy, but it also means the absence of Off-Axis visualization and low operative triangulation possibilities (coaxial surgery).\textsuperscript{14, 38, 45, 51, 58, 72} These facts have made SPA surgery difficult and only feasible for advanced laparoscopic surgeons until now.\textsuperscript{12-14, 25, 27, 80-83} The recent development of new multiple channel port access, as well as the development of dedicated laparoscopic instruments will make LESS surgery more accessible in the near future.\textsuperscript{14, 43, 45, 70, 84} Finally, conversion to standard laparoscopy is easy during LESS and does not involve additional procedures as would be the case during NOTES.\textsuperscript{10, 14, 43} Whether LESS will have an influence on patients’ safety and satisfaction will have to be determined through formal feasibility and randomized studies before diffusing LESS surgery.\textsuperscript{10, 13, 14, 28}

**LESS versus NOTES**

A pure NOTES approach would be the only real form of scarless surgery,\textsuperscript{14, 15, 28, 86} while LESS results in “invisible scar” surgeries.\textsuperscript{13, 14, 28, 51} However, in all reported cases of NOTES except one,\textsuperscript{51} at least one transparietal access was necessary to perform the cholecystectomy.\textsuperscript{28, 53, 35, 87-89} Until now LESS surgery remains less traumatic than the NOTES approach, as it allows...
us to spare healthy organs such as the vagina, stomach or colon, used for NOTES access\(^1\)\(^3\)\(^10\)\(^9\). In this regard LESS may avoid the possible collateral complications of NOTES\(^2\).

Various barriers have to be overcome before the wide clinical application of NOTES and SPA (see Table 2). When reviewing these potential barriers, we concur with Gettman M et al who recently recognized in a NOTES consensus paper that whereas NOTES is still evolving predominantly in the lab, LESS procedures are already being clinically implemented.\(^10\)\(^15\) SPA is a reproduction of a standard laparoscopic operation while only modifying the exposition and dissection techniques\(^1\)\(^4\)\(^\)\(^10\)\(^15\)\(^.

Technical development for single port access surgery

Recently, new trocars for transumbilical LESS surgery have been reported and applied clinically. These proprietary, multiport, single-trocar systems include the TriPort (Advanced Surgical Concepts, Wicklow, Ireland), and the Uni-X single laparoscopic port system (Pnavel Systems, Morganville, NJ, USA)\(^4\)\(^5\)\(^\)\(^6\)\(^8\)\(^2\). However, multiport access through a single incision can be performed using standard laparoscopic trocars placed through adjacent fascial punctures\(^2\)\(^9\)\(^1\)\(^1\).

Newly designed flexible and controlled angled laparoscopic instruments are used clinically (Covidien, Wollerau, Switzerland), or are ready to be introduced by various companies (RealHand; Novare Surgical Systems, Cupertino, CA, USA), (Autonomy Lapro-Angle; Cambridge Endo, Framingham, MA, USA), (Advanced Surgical Concepts, Wicklow, Ireland), and (Pnavel Systems, Morganville, NJ, USA)\(^4\)\(^5\)\(^\)\(^6\)\(^8\)\(^2\). Beside the development of controlled angled instruments, dedicated angled endoscopes have recently been developed (Olympus Surgical, Hamburg, Germany).

In the near future, the possible application of multitask platforms, which are currently under development for NOTES, to single port access surgery may further improve the feasibility of complex procedures with this approach, as does the combination of robotic and single incision approaches\(^3\)\(^1\)\(^1\).

Minimally invasive surgery tomorrow

While being a promising and exciting technique, NOTES seems to still be far from wide clinical application until new instrumentation has been developed and its safety has been demonstrated\(^9\)\(^10\)\(^14\)\(^6\)\(^8\)\(^5\)\(^2\). LESS surgery is ready for clinical application, and laparoscopic surgeons should be prepared for this new surgical approach\(^10\)\(^13\)\(^14\)\(^1\). This requires changing our surgical habits while using the same instrumentation and respecting our surgical principle\(^13\)\(^14\)\(^7\)\(^8\). For this purpose, courses and workshops are set up worldwide, including in our center. Finally, the development of robotics and micro-robotics will influence the development and emergence of these techniques by improving our ability to work through so called “invisible access”\(^10\)\(^14\)\(^1\)\(^1\)\(^1\)\(^1\).

CONCLUSION

Transumbilical LESS surgery has made its initial forays into clinical minimally invasive surgery. The enthusiasm for this new minimally invasive approach may be explained by the relative ease of introduction of this “scarless” surgery clinically and its feasibility by laparoscopic surgeons. Ongoing refinements in technique and instrumentation will expand its future role and open the era of scarless abdominal surgery. Whether LESS will one day replace conventional laparoscopy and the more complex NOTES still needs to be determined.

REFERENCES

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Table 1
Single Port Access Laparoscopic surgeries reported

<table>
<thead>
<tr>
<th>Operation</th>
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<tbody>
<tr>
<td>Appendectomy</td>
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<tr>
<td>Choledectomy</td>
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<td>Inguinal hernia TEP repair</td>
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<td>Prosthetic umbilical hernia repair</td>
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<td>Prosthetic incisional hernia repair</td>
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<td>Right colectomy</td>
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<td>Left colectomy</td>
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<td>Meckel diverticulum resection</td>
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<td>Nissen</td>
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<td>Gastrostomy</td>
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<td>Sleeve gastrectomy</td>
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<td>Perforated duodenal ulcer repair</td>
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<td>Splenectomy</td>
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<td>Necrosectomy for acute pancreatitis</td>
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<td>Distal pancreatectomy</td>
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<td>Bilary cyst fenestration</td>
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<td>Tubal pregnancy</td>
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<td>Hysterectomy (total and subtotal)</td>
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<td>Salpingo-Oophorectomy</td>
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<td>Varicectomy</td>
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<td>Prostatectomy</td>
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<td>Cystectomy</td>
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<td>Nephrectomy (total and partial)</td>
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<td>Reconstructive urology</td>
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<td>Live donor kidney procurement</td>
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<tr>
<td>Adrenalectomy</td>
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<tr>
<td>Transumbilical prosthetic breast augmentation</td>
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1Adapted from references 7, 10, 13-14, 26, 30, 35, 43, 51, 58, 65, 70, 80-82, 94-98