Single-Access Laparoscopic Surgery

Current Applications and Controversies

Giusto Pignata
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Springer

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ISBN 978-3-319-06928-9 ISBN 978-3-319-06929-6 (eBook)
DOI 10.1007/978-3-319-06929-6
Springer Cham Heidelberg Dordrecht London New York

Library of Congress Control Number: 2014945200

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Foreword

It is a pleasure to introduce this volume on the topical subject of single-access laparoscopic surgery. Of the three authors, two, Giusto Pignata and Francesco Corcione, are among the foremost Italian laparoscopic surgeons. The third, Umberto Bracale, trained at major institutions, including those directed by his coauthors, and has dedicated himself enthusiastically to the technique. His contribution to the book represents continuity across generations of surgeons.

The book opens by providing important background information, including with respect to equipment, operating room setting, and devices. An impressive series of chapters, all written by well-known experienced authors, then describe specific procedures, and the book closes with a chapter dedicated to single-access robotic surgery. A consistent approach is adopted throughout the book, with discussion of techniques, advantages, and disadvantages for each application.

It is my belief that this book will be of great benefit not only to those who already have some familiarity with single-access laparoscopic surgery and are seeking to update and refine their knowledge but also to young surgeons, and particularly trainees, who need to be receptive to new techniques.

We have entered an age of "surgical simplification" in which almost all surgeons are using the laparoscopic approach not only in elective settings but also in emergencies, even if, for obvious reasons, conversion to open surgery is still very often necessary. While it may still be difficult today to imagine a laparoscopic surgeon approaching complex liver damage by means of single-access surgery, it must be borne in mind that procedures that seemed impossible only 20 or 30 years ago have become a reality. The capacity of clinical research in developed countries to render surgery simultaneously safer and less invasive, enabling rapid restoration of optimal physical condition, has proved impressive, and one may look to the future expectantly.

Many congratulations are due to those responsible for this book, which, I predict, will prove very successful.

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Preface

Have no fear of perfection. You will never reach it. Salvador Dali

It is a great pleasure to introduce this volume, which has the purpose of acquainting the scientific community with the state-of-the-art and most recent progress in single-access laparoscopic surgery.

The idea of exploring this topic arose from the need to take stock on this new surgical approach, which has been employed more frequently in recent years and has attracted increasing interest from the medical community, a trend reflected in the growing number of citations in scientific publications.

For more accurate analysis of the subject, we selected different experienced surgical teams to write individual chapters on specific topics on which they have a distinguished recent publication record (in terms of quality and number of papers) in international surgical journals. In this way we harvested the experiences of European, American, and Asian surgeons who have dedicated much effort to the development of single-access laparoscopic surgery and its application in clinical practice.

The book seeks to clarify the rationale for single-access laparoscopic surgery, its fields of application, the hypothetical advantages and disadvantages, the advancement of technology necessary for the performance of such procedures, and, above all, the possibility of further development and implementation.

Many thanks are due to Springer for believing in this project and to all the distinguished experts who have contributed to this book, in the hope that it will assist in the development of new minimally invasive techniques, always respecting the health and interests of the patient.

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1 Introduction: From Multiport Laparoscopic Surgery to Single-Port Laparoscopic Surgery

Jacques Marescaux and Michele Diana

1.1 General Considerations

Minimally invasive laparoscopic surgery reduces abdominal parietal trauma while strictly respecting the surgical principles of open surgery. Due to sound and scientifically proven benefits, the laparoscopic approach has become the gold standard for specific interventions such as cholecystectomy, antireflux procedures, and bariatric surgeries, with a worldwide penetration. For more complex procedures, such as colorectal resections, mainly for cancer, the penetration rate among the surgical community is still surprisingly low, reaching barely 40 % in the best cases [1–7]. Lack of adequate training of surgeons, as these are complex and challenging operations with a long learning curve [8], and concerns about oncological safety of the procedure [9] have accounted for this slow uptake. Since Jacobs first described a laparoscopic colectomy in 1991 [10], it has taken a relatively long time and four major clinical trials published between 2002 and 2004 [11–14] to firmly convince skeptical surgeons of the overwhelming advantages of laparoscopy over open surgery in the colorectal field.

Reduction of postoperative pain and of wound complications, reduced formation of intra-abdominal adhesions, shorter hospital stays with reduced medical costs, earlier return to professional activities, and improved cosmetic outcomes are the benefits of the standard multiport approach over conventional large laparotomy incisions.

The achievement of multiport laparoscopic surgery and the continued technological effort to facilitate the spread of this creed have opened further horizons towards even less invasive approaches.

The obvious rationale to persevere in this quest lies in that each abdominal incision carries the risks of morbidity originating from bleeding, hernia, and internal

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_1,

organ injury and exponentially affects cosmetic outcome. In a nutshell, the size and number of incisions matter [15].

This novel surgeon-incision relationship culminated with the concept of natural orifice transluminal endoscopic surgery (NOTES). In NOTES, endoscopes, flexible or rigid, and operating instruments are introduced into the abdominal cavity through natural orifices (stomach, vagina, rectum, or bladder) communicating with the external environment, without any trauma to the abdominal wall. Again in France, 20 years after Mouret's first laparoscopic cholecystectomy, the first transvaginal scarless cholecystectomy was performed in Strasbourg [16] and gave birth to the NOTES era.

This "surgery without scars" may potentially offer reduced, if not inexistent, postoperative pain that could well accelerate the patient's return to daily activities and produce optimal cosmetic results. However, the penetration of NOTES is still very limited, as was laparoscopy in its infancy. Although substantial improvements have been made, the multiple challenges of the technique, namely, the inability to obtain an effective surgical triangulation and to achieve good exposure of the surgical field, have limited patient recruitment. To push the concept forward, further refinements of surgical endoscopic platforms and possibly the integration of robotic assistance are required [17]. The most commonly used current strategy to attempt NOTES without compromising surgical safety is a "hybrid" approach associating a natural orifice access with some transparietal assistance [18–21].

The global brainstorming generated in the attempt to solve the challenges of NOTES has rekindled interest in a probably less disrupting, but certainly more realistic, concept: single-incision surgery or surgery with fewer scars.

Laparoendoscopic single-site surgery (LESS) falls within the same quest to reshape the surgery-incision axiom: a single surgical abdominal access is created through which multiple instruments are inserted simultaneously via a large-caliber single-port device or via small adjacent ports placed into one or multiple fascial incisions [15, 22]. Single-incision surgery has been given a wide range of acronyms and names, including single-incision laparoscopic surgery (SILS), single-access laparoscopic surgery (SALS), single-port access (SPA) surgery, single laparoscopic incision transabdominal (SLIT) surgery, one-port umbilical surgery (OPUS), natural orifice transumbilical surgery (NOTUS), and embryonic natural orifice transumbilical endoscopic surgery (E-NOTES). A recent consortium of experts has finally agreed on the acronym of laparoendoscopic single-site surgery (LESS) [23].

The first descriptions of single-incision laparoscopic digestive surgery date back to more than 10 years [24–26]. However, the approach initially failed to gain popularity due to technical limitations with conventional instrumentation and due to a general lack of advanced laparoscopic skills. Again the same refrain: LESS poses unique difficulties that dramatically hinder the fundamental principle of laparoscopy surgery, i.e., "triangulation," and compromise ergonomics with limited surgical maneuvers and repeated conflicts between instruments, impaired vision, wider umbilical incisions, and a subsequent risk of parietal complications [27]. LESS is another instance that surgical progresses can be made only through a systematic approach to surgical technology innovation and bio-design, where engineers and surgeons create the interface to design specific solutions to deal with specific challenges. We have recently reviewed the current technology armamentarium to cope with LESS [28], which will be further developed in the present book, in a dedicated chapter. LESS has been applied to a variety of procedures, including complex surgeries such as bariatric [29] and colorectal [30].

As per cholecystectomy, which is often the sounding board to test new technologies, there is limited evidence of improved outcomes of LESS when compared to conventional laparoscopic approaches. In a recently published prospective randomized clinical trial comparing LESS vs. standard multiport cholecystectomy [31], including 200 patients with 12 months of follow-up, the LESS group presented higher pain scores ($p=0.028$) and greater wound complication rates ($p=0.047$) when compared to standard four-port cholecystectomy. In addition, operative time was statistically significantly longer in LESS (57 vs. 45 min, $p=0.0001$). Safety profile was similar between the two techniques. The only favorable point for LESS was improved cosmesis score ($p=0.002$).

A recent systematic review and meta-analysis by Markar et al. [32] pooled information from seven randomized trials comparing clinical outcomes between "conventional" multiport vs. LESS cholecystectomy for uncomplicated biliary disease. It showed no statistical difference between both techniques for primary outcomes such as postoperative complications and postoperative pain nor secondary outcomes such as hospital stay. The only statistically significant difference was operative time, which was higher in LESS cholecystectomy.

It has to be pointed out that cholecystectomy is probably not the killer application for LESS, at least with current technology, since it is difficult to perform better than a laparoscopic multiport approach, without increasing operative risks or complexity.

Quite different considerations can be made for LESS in colorectal surgery. There are at least two situations in which a LESS approach can maximize outcomes: the first one is when a protective ileostomy is planned and the future ileostomy site is used as the single access to perform the procedure and to extract the specimen offering a virtual zero scar procedure [30]. The second situation is when a natural orifice specimen extraction (NOSE) is performed to avoid port-site incision enlargement or to perform a mini-laparotomy for surgical specimen extraction and/or to perform the anastomosis [20, 21, 33, 34]. However, efforts are still required to teach and standardize such quite advanced procedures. The next advance in LESS in the colorectal field lies in the optimized use of the Transanal Endoscopic Operation (TEO™) platform, which is basically a single-port device that can allow for pure transanal total mesorectal excision (TME), as could be demonstrated in the experimental [35–37] and clinical setting [38].

1.2 Robotic Assistance and LESS

Robotic research has provided specific technology to facilitate single-incision surgery ruling out the difficulty to achieve surgical triangulation with instruments entering the body from a single surgical access [39]. As outlined by the recent transdisciplinary review by Balaphas et al. [40], the majority of clinical applications of robotic LESS belong to urology and gynecology with only minor experiences in digestive surgery.

The initial experiences with robotic LESS have been performed using the da Vinci® Surgical System robot by Intuitive Surgical, Inc. (the only available surgical robotic platform) in combination with various clinically approved single-port devices (SILS™, GelPort™, and GelPoint™) or through multiple fascial incisions. Ostrowitz successfully completed three right hemicolectomies using a SILS™ port and a single or multiple fascia incisions alternatively [41]. The author experienced some troubles with robotic arms through the SILS™ with cluttering of instruments within the port and a range of motion restriction as well as elevated torque force transferred onto the abdominal wall. To carry on the procedure, an additional port was placed in the umbilicus outside the SILS™ port. Similarly, Romanelli et al. [42] attempted a robotic LESS cholecystectomy through a single skin incision and multiple fascial entries, but the robotic procedure was aborted due to high torque forces resulting in loss of pneumoperitoneum and pursued with hand-held single-incision laparoscopic cholecystectomy. The geometry of the GelPort™ and GelPoint™ used by Singh [43] and Ragupathi [44], respectively, allowed for a greater freedom of movement, and the procedure was completed smoothly.

Recently, Intuitive Surgical, Inc. introduced a specifically designed Robotic Single-Site (VeSPA®) instrumentation. So far only cholecystectomies have been performed in the clinical setting [45–51] using this new platform. The general feeling with these preliminary cases is that robotics simplifies LESS cholecystectomy [50], but still remains more difficult than standard multiport surgery. In the largest series available from a multicenter trial, a 2 % conversion rate to open surgery and only minor intraoperative complications (gallbladder ruptures and minor bleeding) have been reported. In a case-matched study comparing robotic LESS with standard multiport cholecystectomy, Wren et al. [51] reported no difference in total operative time. On the other hand, Spinoglio et al. [50] reported a statistically significant operative time reduction in the robotic LESS group when compared to the “manual” LESS cholecystectomy group ($p < 0.006$). Globally, the da Vinci® Surgical System is an impressive concentrate of technology, accounting for the high costs. Considering the mild benefits for patients demonstrated so far, these costs are prohibitive today. The improvement of robotics should go through changes in the shape of surgical telemanipulators and miniaturization.

1.3 Perspectives for LESS: Miniature Robots and Surgical Endoscopic Platforms

Robotic surgery encounters enthusiastic favors and sarcastic criticisms. It is our personal belief that robotics- and computer-assisted surgery will bring surgery to the next era. However, at least for the digestive tract, new generations of robotic platforms are required. Some promising prototypes are being developed such as the miniature dexterous robot conceived at the Nebraska Medical Center, which can be assembled directly in the abdominal cavity and can perform complex surgical tasks

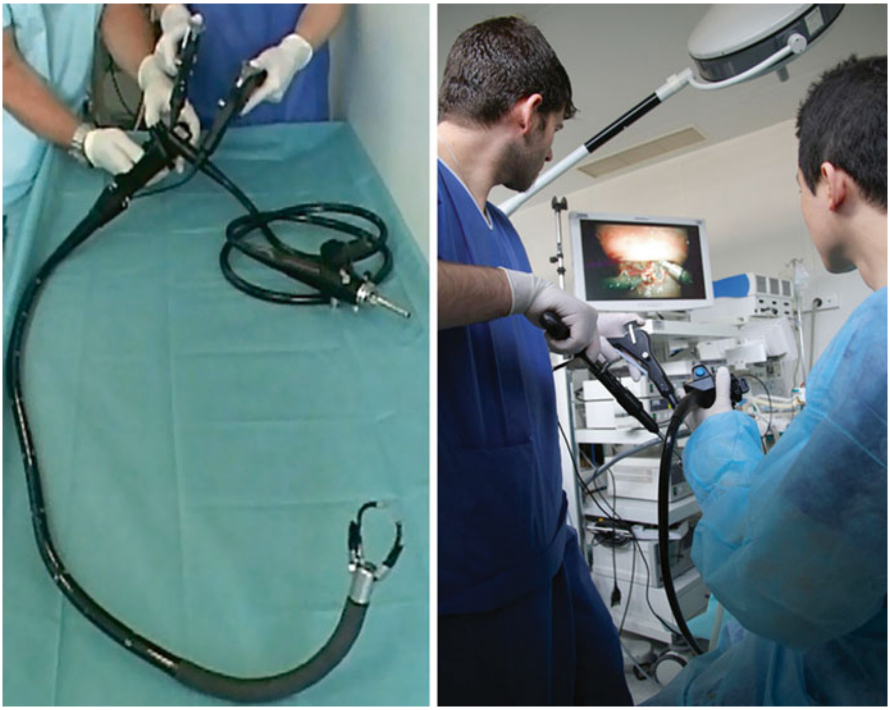

Fig. 1.1 The ANUBISCOPE® (Courtesy of Karl Storz, Tuttlingen, Germany) is a flexible surgical endoscopic platform adapted to Laparo-Endoscopic Single-Site Surgery and to natural orifice transluminal endoscopic surgery. The shaft houses two 4.3-mm and one 3.2-mm working channels to insert operating instruments. The tip opens up like a clam shell to space instruments and offers surgical triangulation. Instruments have an articulated tip, allow for 5° of freedom, and are manipulated by two intuitive handles

[52]. Similarly, the SPRINT (single-port laparoscopy bimanual robot) is a teleoperated mini-robotic system that shows promising results [53] and some snake-like robotic platforms, specifically conceived for single-port surgery [54]. At the IRCAD Institute, we have developed a new surgical endoscopic flexible robotic system that originates from a mechanical hand-held platform, the ANUBISCOPE® (Karl Storz, Tuttlingen, Germany). This platform is composed of a flexible shaft that houses two 4.3-mm and one 3.2-mm working channels. The shaft's tip opens up like a clam shell to space instruments and offers surgical triangulation. Instruments have an articulated tip and allow for 5° of freedom and are manipulated by two intuitive handles (Fig. 1.1). The mechanical device has been used to perform a series of experimental hybrid NOTES procedures [55] and endoluminal procedures such as colonic endoscopic submucosal dissection (ESD) [17]. A shorter version of the ANUBISCOPE®, the ISISSCOPE®, 55 cm in length and 1.8 cm in diameter, has been successfully used in the clinical setting to perform single-port cholecystectomy [56]. The robotic version is telemanipulated through an intuitive haptic interface that allows for very smooth and controlled micromovements (Fig. 1.2). It has

Fig. 1.2 The robotic version of the ISISSCOPE® (Courtesy of Karl Storz, Tuttlingen, Germany) is telemanipulated through an intuitive haptic interface that allows for very smooth and controlled micromovements

so far been used to perform ex vivo tests such as endoscopic submucosal dissections in porcine stomachs and colons, showing a high agility as well as the ability to transfer a sufficient amount of force for traction, suturing, knot tying, and dissection.

Conclusions

LESS has the potential to positively influence incision-related morbidity, cosmetic outcome, and overall perioperative morbidity in selected procedures. Specifically applied to the colorectal field, LESS may offer enhanced recovery, particularly when coupled with natural orifice specimen extraction or when the site of a planned stoma is used as the access point. However, the uptake of LESS will depend on further technological developments as well as on the creation and implementation of new generations of miniature robotic platforms.

References

1. Kemp JA, Finlayson SR (2008) Outcomes of laparoscopic and open colectomy: a national population-based comparison. Surg Innov 15:277–283
2. Delaney CP, Chang E, Senagore AJ, Broder M (2008) Clinical outcomes and resource utilization associated with laparoscopic and open colectomy using a large national database. Ann Surg 247:819–824
3. Harinath G, Shah PR, Haray PN, Foster ME (2005) Laparoscopic colorectal surgery in Great Britain and Ireland–where are we now? Colorectal Dis 7:86–89
4. Schwab KE, Dowson HM, Van Dellen J, Marks CG, Rockall TA (2009) The uptake of laparoscopic colorectal surgery in Great Britain and Ireland: a questionnaire survey of consultant members of the ACPGBI. Colorectal Dis 11:318–322
5. Romy S, Eisenring MC, Bettschart V, Petignat C, Francioli P, Troillet N (2008) Laparoscope use and surgical site infections in digestive surgery. Ann Surg 247:627–632

6. Hubner M, Diana M, Zanetti G, Eisenring MC, Demartines N, Troillet N (2011) Surgical site infections in colon surgery: the patient, the procedure, the hospital, and the surgeon. Arch Surg 146:1240–1245
7. Diana M, Hubner M, Eisenring MC, Zanetti G, Troillet N, Demartines N (2011) Measures to prevent surgical site infections: what surgeons (should) do. World J Surg 35:280–288
8. Tekkis PP, Senagore AJ, Delaney CP, Fazio VW (2005) Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. Ann Surg 242:83–91
9. Kazemier G, Bonjer HJ, Berends FJ, Lange JF (1995) Port site metastases after laparoscopic colorectal surgery for cure of malignancy. Br J Surg 82:1141–1142
10. Jacobs M, Verdeja JC, Goldstein HS (1991) Minimally invasive colon resection (laparoscopic colectomy). Surg Laparosc Endosc 1:144–150
11. Lacy AM, Garcia-Valdecasas JC, Delgado S, Castells A, Taura P, Pique JM, Visa J (2002) Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: a randomised trial. Lancet 359:2224–2229
12. Clinical Outcomes of Surgical Therapy Study Group (2004) A comparison of laparoscopically assisted and open colectomy for colon cancer. N Engl J Med 350:2050–2059
13. Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, Heath RM, Brown JM (2005) Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet 365:1718–1726
14. Veldkamp R, Kuhry E, Hop WC, Jeekel J, Kazemier G, Bonjer HJ, Haglind E, Pahlman L, Cuesta MA, Msika S, Morino M, Lacy AM (2005) Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. Lancet Oncol 6:477–484
15. Mostafa G, Matthews BD, Sing RF, Kercher KW, Heniford BT (2001) Mini-laparoscopic versus laparoscopic approach to appendectomy. BMC Surg 1:4
16. Marescaux J, Dallemagne B, Perretta S, Wattiez A, Mutter D, Coumaros D (2007) Surgery without scars: report of transluminal cholecystectomy in a human being. Arch Surg 142: 823–826; discussion 826–827
17. Diana M, Chung H, Liu KH, Dallemagne B, Demartines N, Mutter D, Marescaux J (2013) Endoluminal surgical triangulation: overcoming challenges of colonic endoscopic submucosal dissections using a novel flexible endoscopic surgical platform: feasibility study in a porcine model. Surg Endosc 27:4130–4135
18. Sylla P, Rattner DW, Delgado S, Lacy AM (2010) NOTES transanal rectal cancer resection using transanal endoscopic microsurgery and laparoscopic assistance. Surg Endosc 24:1205–1210
19. Dallemagne B, Perretta S, Allemann P, Asakuma M, Marescaux J (2009) Transgastric hybrid cholecystectomy. Br J Surg 96:1162–1166
20. Diana M, Perretta S, Wall J, Costantino FA, Leroy J, Demartines N, Marescaux J (2011) Transvaginal specimen extraction in colorectal surgery: current state of the art. Colorectal Dis 13:e104–e111
21. Diana M, Wall J, Costantino F, D'Agostino J, Leroy J, Marescaux J (2011) Transanal extraction of the specimen during laparoscopic colectomy. Colorectal Dis 13(Suppl 7):23–27
22. Mutter D, Callari C, Diana M, Dallemagne B, Leroy J, Marescaux J (2011) Single port laparoscopic cholecystectomy: which technique, which surgeon, for which patient? A study of the implementation in a teaching hospital. J Hepatobiliary Pancreat Sci 18:453–457
23. Gill IS, Advincula AP, Aron M, Caddedu J, Canes D, Curcillo PG 2nd, Desai MM, Evanko JC, Falcone T, Fazio V, Gettman M, Gumbs AA, Haber GP, Kaouk JH, Kim F, King SA, Ponsky J, Remzi F, Rivas H, Rosemurgy A, Ross S, Schauer P, Sotelo R, Speranza J, Sweeney J, Teixeira J (2010) Consensus statement of the consortium for laparoendoscopic single-site surgery. Surg Endosc 24:762–768
24. Navarra G, Pozza E, Occhionorelli S, Carcoforo P, Donini I (1997) One-wound laparoscopic cholecystectomy. Br J Surg 84:695
25. Rispoli G, Armellino MF, Esposito C (2002) One-trocar appendectomy. Surg Endosc 16:833–835

26. Piskun G, Rajpal S (1999) Transumbilical laparoscopic cholecystectomy utilizes no incisions outside the umbilicus. J Laparoendosc Adv Surg Tech A 9:361–364
27. Edwards C, Bradshaw A, Ahearne P, Dematos P, Humble T, Johnson R, Mauterer D, Soosaar P (2010) Single-incision laparoscopic cholecystectomy is feasible: initial experience with 80 cases. Surg Endosc 24:2241–2247
28. Dhumane PW, Diana M, Leroy J, Marescaux J (2011) Minimally invasive single-site surgery for the digestive system: a technological review. J Minim Access Surg 7:40–51
29. Huang CK (2011) Single-incision laparoscopic bariatric surgery. J Minim Access Surg 7:99–103
30. Diana M, Dhumane P, Cahill RA, Mortensen N, Leroy J, Marescaux J (2011) Minimal invasive single-site surgery in colorectal procedures: current state of the art. J Minim Access Surg 7:52–60
31. Phillips MS, Marks JM, Roberts K, Tacchino R, Onders R, DeNoto G, Rivas H, Islam A, Soper N, Gecelter G, Rubach E, Paraskeva P, Shah S (2012) Intermediate results of a prospective randomized controlled trial of traditional four-port laparoscopic cholecystectomy versus single-incision laparoscopic cholecystectomy. Surg Endosc 26:1296–1303
32. Markar SR, Karthikesalingam A, Thrumurthy S, Muirhead L, Kinross J, Paraskeva P (2012) Single-incision laparoscopic surgery (SILS) vs. conventional multiport cholecystectomy: systematic review and meta-analysis. Surg Endosc 26:1205–1213
33. Leroy J, Diana M, Wall J, Costantino F, D'Agostino J, Marescaux J (2011) Laparo-endoscopic single-site (LESS) with transanal natural orifice specimen extraction (NOSE) sigmoidectomy: a new step before pure colorectal natural orifices transluminal endoscopic surgery (NOTES(R)). J Gastrointest Surg 15:1488–1492
34. Costantino FA, Diana M, Wall J, Leroy J, Mutter D, Marescaux J (2012) Prospective evaluation of peritoneal fluid contamination following transabdominal vs. transanal specimen extraction in laparoscopic left-sided colorectal resections. Surg Endosc 26:1495–1500
35. Diana M, Leroy J, Wall J, De Ruijter V, Lindner V, Dhumane P, Mutter D, Marescaux J (2012) Prospective experimental study of transrectal viscerotomy closure using transanal endoscopic suture vs. circular stapler: a step toward NOTES. Endoscopy 44:605–611
36. Leroy J, Diana M, Barry B, Mutter D, Melani AG, Wu HS, Marescaux J (2012) Perirectal Oncologic Gateway to Retroperitoneal Endoscopic Single-Site Surgery (PROGRESSS): a feasibility study for a new NOTES approach in a swine model. Surg Innov 19:345–352
37. Leroy J, Diana M, Perretta S, Wall J, De Ruijter V, Marescaux J (2011) Original technique to close the transrectal viscerotomy access in a NOTES transrectal and transgastric segmental colectomy. Surg Innov 18:193–200
38. Leroy J, Barry BD, Melani A, Mutter D, Marescaux J (2013) No-scar transanal total mesorectal excision: the last step to pure NOTES for colorectal surgery. JAMA Surg 148:226–230; discussion 231
39. Allemann P, Leroy J, Asakuma M, Al Abeidi F, Dallemagne B, Marescaux J (2010) Robotics may overcome technical limitations of single-trocar surgery: an experimental prospective study of Nissen fundoplication. Arch Surg 145:267–271
40. Balaphas A, Hagen ME, Buchs NC, Pugin F, Volonte F, Inan I, Morel P (2013) Robotic laparoendoscopy single site surgery: a transdisciplinary review. Int J Med Robot 9:1–11
41. Ostrowitz MB, Eschete D, Zemon H, DeNoto G (2009) Robotic-assisted single-incision right colectomy: early experience. Int J Med Robot 5:465–470
42. Romanelli JR, Roshek TB 3rd, Lynn DC, Earle DB (2010) Single-port laparoscopic cholecystectomy: initial experience. Surg Endosc 24:1374–1379
43. Singh J, Podolsky ER, Castellanos AE, Stein DE (2011) Optimizing single port surgery: a case report and review of technique in colon resection. Int J Med Robot 7:127–130
44. Ragupathi M, Ramos-Valadez DI, Pedraza R, Haas EM (2010) Robotic-assisted single-incision laparoscopic partial cecectomy. Int J Med Robot 6:362–367
45. Buchs NC, Hagen ME, Pugin F, Volonte F, Bucher P, Schiffer E, Morel P (2012) Intra-operative fluorescent cholangiography using indocyanin green during robotic single site cholecystectomy. Int J Med Robot 8(4):436–440. doi: 10.1002/rcs.1437

46. Konstantinidis KM, Hirides P, Hirides S, Chrysocheris P, Georgiou M (2012) Cholecystectomy using a novel Single-Site((R)) robotic platform: early experience from 45 consecutive cases. Surg Endosc 26:2687–2694
47. Kroh M, El-Hayek K, Rosenblatt S, Chand B, Escobar P, Kaouk J, Chalikonda S (2011) First human surgery with a novel single-port robotic system: cholecystectomy using the da Vinci single-site platform. Surg Endosc 25:3566–3573
48. Morel P, Hagen ME, Bucher P, Buchs NC, Pugin F (2011) Robotic single-port cholecystectomy using a new platform: initial clinical experience. J Gastrointest Surg 15:2182–2186
49. Pietrabissa A, Sbrana F, Morelli L, Badessi F, Pugliese L, Vinci A, Klersy C, Spinoglio G (2012) Overcoming the challenges of single-incision cholecystectomy with robotic single-site technology. Arch Surg 147(8):709–714
50. Spinoglio G, Lenti LM, Maglione V, Lucido FS, Priora F, Bianchi PP, Grosso F, Quarati R (2012) Single-site robotic cholecystectomy (SSRC) versus single-incision laparoscopic cholecystectomy (SILC): comparison of learning curves. First European experience. Surg Endosc 26:1648–1655
51. Wren SM, Curet MJ (2011) Single-port robotic cholecystectomy: results from a first human use clinical study of the new da Vinci single-site surgical platform. Arch Surg 146:1122–1127
52. Dolghi O, Strabala KW, Wortman TD, Goede MR, Farritor SM, Oleynikov D (2011) Miniature in vivo robot for laparoendoscopic single-site surgery. Surg Endosc 25:3453–3458
53. Petroni G, Niccolini M, Menciassi A, Dario P, Cuschieri A (2013) A novel intracorporeal assembling robotic system for single-port laparoscopic surgery. Surg Endosc Feb 27(2):665–670
54. Mahvash M, Zenati M (2011) Toward a hybrid snake robot for single-port surgery. Conf Proc IEEE Eng Med Biol Soc 2011:5372–5375
55. Leroy J, Diana M, Barry B, Mutter D, Melani AG, Wu HS, Marescaux J (2012) Perirectal Oncologic Gateway to Retroperitoneal Endoscopic Single-Site Surgery (PROGRESSS): a feasibility study for a new NOTES approach in a swine model. Surg Innov 9(4):345–352
56. Perretta S, Dallemagne B, Barry B, Marescaux J (2013) The ANUBISCOPE((R)) flexible platform ready for prime time: description of the first clinical case. Surg Endosc 27(7):2630

Single-Incision Laparoscopic Appendectomy

2

Enders Kwok-wai Ng and Anthony Yuen-bun Teoh

2.1 Introduction

Acute appendicitis is one of the most common abdominal surgical emergencies in modern hospital practice. The estimated incidence ranges from 7 to 12 % in the populations of the USA and Europe [1, 2]. It is most common between the ages of 5 and 40, with a median age at 28 years. Approximately 8 % of the population in the developed world can expect to undergo appendectomy for acute appendicitis during their lifetime [3]. Though a slight male preponderance is reported, operation based on a presumptive diagnosis of appendicitis is more common in women, mainly because of other mimicking pelvic conditions.

The first appendectomy in human race was described by McBurney more than 100 years ago [4]. It is an effective treatment for acute appendicitis, which allows majority of patients to recover without much morbidity. The operation saves many young lives who otherwise would have been dead if living in the ancient ages when surgery was unavailable.

The adoption of laparoscopic technique in appendectomy was first reported by Semm in 1983 [5]. Since then there has been a steady increase in acceptance of laparoscopic appendectomy. The technique has indeed evolved over the past two decades, with different advocates on positioning and number of the working trocars. The benefit of using accessories other than conventional monopolar electrocautery, such as ultrasonic shears, bipolar energy devices, and endostaplers, has also been described [6–8]. Initially, there was skepticism about the safety and justification of laparoscopic appendectomy because the conventional open method had already been a reliable and cost-effective treatment for most acute appendicitis. However, these controversies had gradually resolved when a number of randomized studies and quality meta-analyses were published.

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_2, © Springer International Publishing Switzerland 2014

2.2 Advantages of Laparoscopic Appendectomy

The advantages of laparoscopic appendectomy over the open approach have been extensively studied over the last 20 years, although individual studies have produced rather conflicting results [9–11]. In a review by the Cochrane Collaboration group including 67 clinical studies, laparoscopic appendectomy had been associated with significantly reduced risk of wound infection, reduced postoperative pain, shorter hospital stay (−1 day), and more rapid return to normal activities [12]. The disadvantages of laparoscopic appendectomy were a longer duration of the operation (+10 min) and a higher rate of intraabdominal abscesses. More importantly, the laparoscopic approach for suspected appendicitis conferred additional diagnostic to therapeutic advantages for some patients, especially in child-bearing age women. Nowadays, it has already become the first-line treatment in the management protocol for suspected appendicitis in many institutes around the world.

2.3 Development of SILA

There was once a rapid growth of enthusiasm in developing natural orifice transluminal endoscopic surgery (NOTES) when Rao et al. reported their success in performing a clinical per-oral transgastric appendectomy at the World Congress of Gastroenterology in 2005 [13]. It sparked off a wave of interest in trying this novel approach in both animal and human settings to test its feasibility and safety [14]. Special platforms for NOTES procedures were built for such purposes. However, apparently there is still a considerable hurdle before NOTES can be widely practiced because of a significant technological gap in instrumentation. Most reported series of NOTES appendectomy were of small scale using the transgastric and transvaginal routes [15–17]. Nevertheless, at around the same period of time, some gastroenterologists attempted cholecystectomy with the flexible endoscope through an umbilical incision, considering the umbilicus as one of the "embryologic" natural orifices (also called e-NOTES) [18]. This aroused and reactivated the interest of general surgeons to start a variety of laparoscopic operations, including appendectomy, through a small periumbilical incision.

The concept of single-incision appendectomy was not new. It could be dated back to 1992 when Pelosi reported the first series of single-trocar appendectomy in 25 patients [19]. In 1999, Valla et al. reported a larger retrospective series of 200 pediatric appendicitis, to whom an umbilical one-puncture laparoscopic-assisted appendectomy (UOPLAA) was successful in 184 patients [20]. Additional trocar insertion was required in 16 patients because of perforated or retrocecal appendicitis. Mean operation time was 15 min and hospital stay was only 2 days, but no comparison with ordinary laparoscopic appendectomy was made. Subsequently, D' Alessio et al. reported another series of pediatric patients [21]. Among them, one-trocar transumbilical laparoscopic-assisted appendectomy (TULAA) was successfully performed in 116, while 28 other patients were converted to multiple trocars and 6 more patients to open surgery. The median hospital stay was shortest in the group with successful one-trocar appendectomy (7 days) when compared to those with conversion to multi-trocars (10 days) or open surgery (14 days). However, all these earlier series did not attract much attention at their time of publication because the concept of NOTES was yet to sprout.

In 2007, concomitant to the fast-growing interest in NOTES and e-NOTES, specially designed trocars became available. Ates et al. attempted single-incision laparoscopic appendectomy using a double working-channel trocar system (Applied Medical, CA, USA) in 38 pediatric cases [22]. A laparoscope with an offset eyepiece and 6-mm working channel was employed. Transabdominal sling suture was applied to retract the vermiform appendix and facilitate mesoappendix dissection. Success was achieved in 35 patients, with a mean hospital stay of 2.1 +/− 1.2 days, which compared favorably to an earlier cohort of patients undergoing conventional 3-port appendectomy in the same institute, but statistically the difference was insignificant. In another case-controlled comparison, 30 patients that received single-incision laparoscopic appendectomy were compared with 60 patients who underwent conventional laparoscopic appendectomy [23]. A single transumbilical wound with multiple port insertion was used. No significant differences in operative time, hospital stay, and morbidity rates were observed.

Since then there has been an increasing number of prospective and retrospective series of SILA reported in the literature. Initially it focused more on the benefit and cosmetic appeal in the pediatric groups, but later the single-incision technique was also extended to adult patients with acute appendicitis. Essentially, there are three different approaches in siting the wound.

2.4 Techniques

The intracorporeal dissection of the mesoappendix and closure of the appendiceal stump in SILA are quite similar to that of the conventional 3-port laparoscopic appendectomy. There have been advocates of using more robust dissecting/coagulating devices such as bipolar forceps, ultrasonic dissectors (Fig. 2.1), the LigaSure, and even endostapler, but these are not absolutely necessary [24–26]. The choice of laparoscopic instruments lies on the individual surgeon's discretion and also cost consideration in different institutes (Fig. 2.2).

On the other hand, there are at least three different approaches to site and handle the wound, and there is yet any consensus as to which one is better.

1. *Single fascial incision*

   Commercially, there is a number of proprietary, multilumen, single-trocar systems specifically designed for single-incision surgery. The more commonly used ones include the TriPort (Olympus Medical), the SILS port (Covidien), the CX Cone (Karl Storz), and some gel port systems (Figs. 2.3 and 2.4). All these devices share the concept that only one single fascial incision (usually transumbilical) is required for passage of the composite port through which the laparoscope and instruments are inserted into the abdominal cavity. Theoretically, they minimize friction injury to the soft tissues at wound site and reduce inadvertent

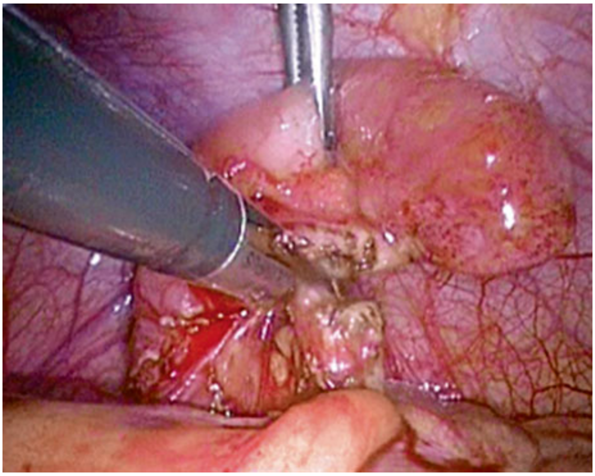

Fig. 2.1 Use of a flexible and roticulating tip forceps and an ultrasonic dissector during single-incision laparoscopic appendectomy

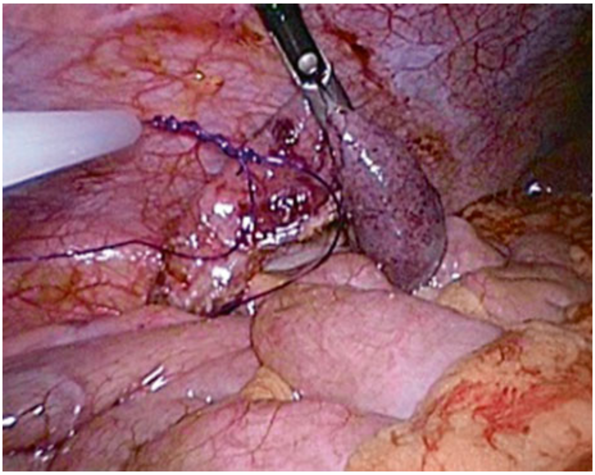

Fig. 2.2 Use of Endoloop (5 mm) for closure of the appendiceal stump before transection of the appendix

damage to the shaft of laparoscopic instrument during manipulation. Cost is one of the prohibitory factors why surgeons do not use them more often.

Alternatively, some surgeons adopt the so-called "glove-port" method when performing SILA [27]. In brief, a small fascial incision about 2–2.5 cm is made through the umbilicus. A small-sized wound retractor is inserted across this fascial wound using the Hasson technique. A sterile latex glove is mounted onto the external rubber ring of the wound retractor, and multiple plastic or metal trocars are then inserted through the glove into the peritoneal cavity for passage of video telescope and other laparoscopic instruments.

2. *Single skin wound with multiple fascial incisions*
   Instead of using the single fascial incision technique, which may entail the cost of expensive composite port systems, some surgeons opt for making a single skin

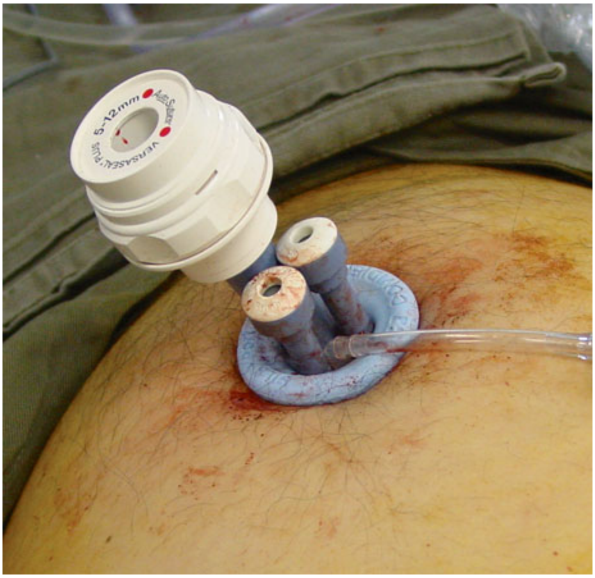

Fig. 2.3 The LESS port (Courtesy of Covidien, MA, USA) for SILA

Fig. 2.4 The TriPort (Courtesy of Olympus, Tokyo, Japan) being used for SILA

incision either transumbilically or infraumbilically in a curvilinear manner. Subcutaneous dissection is performed under the skin incision to allow exposure of a small area of anterior rectus fascia. Trocars of 5 mm or 10 mm are then inserted through different fascial incisions made in this wound. To minimize collision of instruments at the entry point, low-profile trocars bearing smaller external components are preferred. This technique is less expensive than the single-port method, but it may also be the culprit of more postoperative wound pain and surgical site complications such as bruises, hematoma, and infection.

3. *Suprapubic single-incision approach*
   Some surgeons considered a transumbilical scar is cosmetically unsightly and a disadvantage of SILA. They proposed using the suprapubic approach for SILS so that the visible part of the abdomen could be left with no scars [28, 29]. One of the advantages of this approach includes a better view of the appendix and its base, thus avoids inadvertent injury to the cecum especially in retrocecal and gangrenous appendicitis. Another advantage is the close proximity of the suprapubic wound to the pelvis, which facilitates rinsing of the area safely in case of a ruptured appendicitis. While initial reports claimed better cosmetic outcomes with an acceptable operation time and relatively low wound pain score with this approach, clinical pictures of scars published in these articles were not quite appealing. Some of them appeared as if a conventional McBurney's incision had been shifted to the hypogastrium.

2.5 Current Evidence

Many of the earlier series of SILA were single-arm studies. Most of them confirmed that SILA was a feasible and safe option in the management of uncomplicated acute appendicitis. Subsequently, some comparative studies had also been published but were based largely on retrospective data with small sample size [30, 31].

It was not until 5 years after Ates's series that St. Peter et al. and Teoh et al. reported the first truly randomized trial comparing SILA versus conventional 3-port appendectomy in children and adults, respectively [32, 33]. Of the 200 patients recruited in Teoh's study, 98 SILA and 97 3-port appendectomies had complete set of data for further analysis. While there were no difference between the two groups in the morbidity rates, operative time, conversion rates, overall pain score, and pain score at rest, those with SILA did have significant more pain upon coughing or standing and required more intravenous analgesics ($p = 0.001$, 0.038, and 0.035, respectively). On the other hand, cosmetic satisfaction was better in the SILA group when compared to the 3-port appendectomy group.

There were at least three more randomized trials published afterwards [34–36]. Many systematic reviews and meta-analyses have also been released recently. The latest meta-analysis includes 5 randomized trials covering a total of 746 patients [37]. Thirty-day morbidity and wound infection rates were similar between SILA and conventional laparoscopic appendectomy, but SILA required a significantly longer operating duration to accomplish. More importantly, despite pooling of information from over 700 patients, the authors commented that the available data were not robust enough to reach any conclusions regarding hospital stay, postoperative wound pain, and open conversion.

The lack of instrument triangulation in SILA often results in poor ergonomics, which may be reflected by the increased operating time seen for SILA. It is noteworthy that in another meta-analysis, it was revealed that about 7 % of patients needed the insertion of an additional port, even in the hands of experienced laparoscopic surgeons with a low open conversion rate [38].

If SILA is not inferior to conventional 3-port laparoscopic appendectomy in terms of safety, it seems that the price to pay for a cosmetic benefit is the longer operating time. However, St. Peter et al. reviewed the cost-effectiveness of the two procedures and demonstrated significantly higher hospital cost associated with SILA (US$17,600 ± 4,000) versus conventional laparoscopic appendectomy (US$16,600 ± 3,900; $p = 0.005$). It is probably due to the use of extra equipment in addition to the longer operating room usage.

2.6 Future Perspectives

There is currently little evidence available regarding the effectiveness of SILA in specific challenging patient cohorts, including obese and elderly patients and those with multiple medical comorbidities. As some surgeons use a multiport device through a single fascial incision for the insertion of laparoscopic instruments, whereas others use three separate trocars through multiple fascial incisions, it is not sure which technique may end up with more incisional herniation in the long term. All these could be interesting areas of future research.

References

1. Ellis H (2012) Acute appendicitis. Br J Hosp Med 73:C46–C48
2. Addiss DG, Shaffer N, Fowler BS et al (1990) The epidemiology of appendicitis and appendectomy in the United States. Am J Epidemiol 132:910–925
3. Hale DA, Molloy M, Pearl RH et al (1997) Appendectomy: a contemporary appraisal. Ann Surg 225:252–261
4. (1983) Classic articles in colonic and rectal surgery. Charles Heber McBurney 1845–1913. Dis Colon Rectum 26:291–303
5. Semm K (1983) Endoscopic appendectomy. Endoscopy 15:59–64
6. Tan HL, Segawa O, Stein JE (1995) Laparoscopic bipolar strip-tease appendicectomy. A new endosurgical technique. Surg Endosc 9:1301–1303
7. Yang HR, Wang YC, Chung PK, Jeng LB, Chen RJ (2005) Laparoscopic appendectomy using the LigaSure vessel sealing system. J Laparoendosc Adv Surg Tech A 15:353–356
8. del Olmo JC M, Blanco Alvarez JI, Carbajo Caballero MA et al (2002) Laparoscopic appendectomy by ultrasonically activated scalpel in acute appendicitis: preliminary report. J Laparoendosc Adv Surg Tech A 12:111–113
9. Cox MR, McCall JL, Toouli J et al (1996) Prospective randomized comparison of open versus laparoscopic appendectomy in men. World J Surg 20:263–266
10. Katkhouda N, Mason RJ, Towfigh S et al (2005) Laparoscopic versus open appendectomy: a prospective randomized double-blind study. Ann Surg 242:439–448
11. Kouhia ST, Heiskanen JT, Huttunen R et al (2010) Long-term follow-up of a randomized clinical trial of open versus laparoscopic appendicectomy. Br J Surg 97:1395–1400
12. Sauerland S, Jaschinski T, Neugebauer EA (2010) Laparoscopic versus open surgery for suspected appendicitis. Cochrane Database Syst Rev (10):CD001546
13. Rao GV, Reddy DN, Banerjee R (2008) NOTES: human experience. Gastrointest Endosc Clin N Am 18:361–370
14. Kalloo AN et al (2004) Flexible transgastric peritoneoscopy: a novel approach to diagnostic and therapeutic interventions in the peritoneal cavity. Gastrointest Endosc 60:114–117

15. Park PO, Bergstrom M (2010) Transgastric peritoneoscopy and appendectomy: thoughts on our first experience in humans. Endoscopy 42:81–84
16. Tabutsadze T, Kipshidze N (2009) New trend in endoscopic surgery: transvaginal appendectomy NOTES (Natural Orifice Transluminal Endoscopic Surgery). Georgian Med News 168:7–10
17. Shin EJ, Jeong GA, Jung JC et al (2010) Transvaginal endoscopic appendectomy. J Kor Soc Coloproctol 26:429–432
18. Palanivelu C, Rajan PS, Rangarajan M et al (2008) Transumbilical flexible endoscopic cholecystectomy in humans: first feasibility study using a hybrid technique. Endoscopy 40:428–431
19. Pelosi MA, Pelosi MA 3rd (1992) Laparoscopic appendectomy using a single umbilical puncture (minilaparoscopy). J Reprod Med 37:588–594
20. Valla J, Ordorica-Flores RM, Steyaert H et al (1999) Umbilical one-puncture laparoscopic-assisted appendectomy in children. Surg Endosc 13:83–85
21. D'Alessio A, Piro E, Tadini B et al (2002) One-trocar transumbilical laparoscopic-assisted appendectomy in children: our experience. Eur J Pediatr Surg 12:24–27
22. Ateş O, Hakgüder G, Olguner M et al (2007) Single-port laparoscopic appendectomy conducted intracorporeally with the aid of a transabdominal sling suture. J Pediatr Surg 42: 1071–1074
23. Teoh AY, Chiu PW, Wong TC et al (2011) A case-controlled comparison of single-site access versus conventional three-port laparoscopic appendectomy. Surg Endosc 25:1415–1419
24. Graur F, Elisei R, Al-Hajjar N (2013) E-NOTES transumbilical laparoscopic appendectomy. Chir (Bucur) 108:571–575
25. Nguyen NT, Reavis KM, Hinojosa MW et al (2009) A single-port technique for laparoscopic extended stapled appendectomy. Surg Innov 16:78–81
26. Pan Z, Jiang XH, Zhou JH et al (2013) Transumbilical single-incision laparoscopic appendectomy using conventional instruments: the single working channel technique. Surg Laparosc Endosc Percutan Tech 23:208–211
27. Hong TH, Kim HL, Lee YS et al (2009) Transumbilical single-port laparoscopic appendectomy (TUSPLA): scarless intracorporeal appendectomy. J Laparoendosc Adv Surg Tech A 19:75–78
28. Vidal O, Ginestà C, Valentini M et al (2011) Suprapubic single-incision laparoscopic appendectomy: a nonvisible-scar surgical option. Surg Endosc 25:1019–1023
29. Yu J, Wang YN, Hu YF et al (2011) Single-incision laparoscopic appendectomy performed above the pubic symphysis – a new scarless approach. Minim Invasive Ther Allied Technol 20:18–21
30. Cho MS, Min BS, Hong YK et al (2011) Single-site versus conventional laparoscopic appendectomy: comparison of short-term operative outcomes. Surg Endosc 25:36–40
31. Chow A, Purkayastha S, Nehme J et al (2010) Single incision laparoscopic surgery for appendicectomy: a retrospective comparative analysis. Surg Endosc 24:2567–2574
32. St Peter SD, Adibe OO, Juang D et al (2011) Single incision versus standard 3-port laparoscopic appendectomy: a prospective randomized trial. Ann Surg 254:586–590
33. Teoh AY, Chiu PW, Wong TC et al (2012) A double-blinded randomized controlled trial of laparoendoscopic single-site access versus conventional 3-port appendectomy. Ann Surg 256:909–914
34. Frutos MD, Abrisqueta J, Lujan J et al (2013) Randomized prospective study to compare laparoscopic appendectomy versus umbilical single-incision appendectomy. Ann Surg 257: 413–418
35. Lee WS, Choi ST, Lee JN et al (2013) Single-port laparoscopic appendectomy versus conventional laparoscopic appendectomy: a prospective randomized controlled study. Ann Surg 257:214–218

36. Sozutek A, Colak T, Dirlik M et al (2013) A prospective randomized comparison of single-port laparoscopic procedure with open and standard 3-port laparoscopic procedures in the treatment of acute appendicitis. Surg Laparosc Endosc Percutan Tech 23:74–78
37. Antoniou SA, Koch OO, Antoniou GA et al (2014) Meta-analysis of randomized trials on single-incision laparoscopic versus conventional laparoscopic appendectomy. Am J Surg 207:613–622
38. Markar SR, Karthikesalingam A, Di Franco F et al (2013) Systematic review and meta-analysis of single-incision versus conventional multiport appendicectomy. Br J Surg 100:1709–1718

3 Single-Access Laparoscopic Repair of Abdominal Wall Hernias

Paul M. Wilkerson and Yuen Soon

3.1 Introduction

Laparoscopic repair of abdominal wall hernias ranging from inguinal [1–4] to complex incisional ventral hernias [5–8] has been widely published. In the case of inguinal hernia repair, NICE has published guidance on the subject, recommending that laparoscopic inguinal hernia repair is the procedure of choice for bilateral and recurrent inguinal hernias (NICE technology appraisal TA83, www.guidance.nice.org.uk/TA83). Furthermore, they suggest that the laparoscopic approach shows equivalence for unilateral primary inguinal hernias, and the British Hernia Society guidelines have suggested that the laparoscopic approach may be preferable in younger patients with primary hernias due to the reduction in chronic groin pain in these patients (www.britishherniasociety.org/hernia-guidelines-2/).

The scope of this chapter is therefore not to discuss the appropriateness of laparoscopic abdominal wall hernia repair. Rather, the aim of this chapter is to discuss the technical aspects of single-access laparoscopic surgery (SALS) and how these principles are applied to abdominal wall hernia repairs. Much of this will be the

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_3,

author's own opinion, but a brief discussion of the available literature (which is not extensive) will then follow.

3.2 Technical Aspects of the SALS Approach

3.2.1 Equipment

3.2.1.1 Ports

There are a number of ports available for SALS access. This ranges from "home-made" devices, multi-fascial ports to commercially available ports. The author has personal experience of the majority of access techniques described for SALS. There are a number of aspects of port design to consider when surgeons select their preferred port.

First, one must consider the width and depth of the port or access device (Fig. 3.1). The deeper the access device, the more limited the internal and external range of movement will be, as the edge of the device will be further from the instrument fulcrum point. The wider the access device, the bigger the capacity for triangulation, which will be balanced against the size of the incision required for placement. These features may have an impact on the ease of the procedure. Second, the various access devices have different numbers of access channels, and this should be considered in the context of the proposed procedure. For example, the TriPort+ (Olympus) and the SILS port (Covidien) each have capacity for four channels, while the GelPort (Applied Medical) can have three or four access channels.

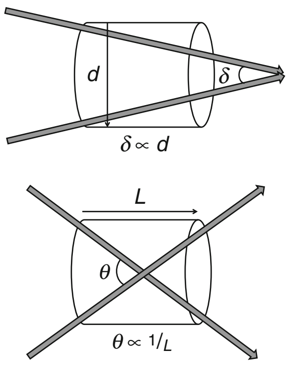

Fig. 3.1 The effect of port length and width on range of movement and triangulation. As the port width (d) is increased, the angle at which instruments meet at the target organ (δ) is increased. This equates to a greater ability to triangulate instruments on the target, a feature of laparoscopic surgery that is often diminished by the SALS approach. Conversely, as the length (L) of the port is increased, the maximum angle at which instruments cross (Θ) within the port is reduced. This limits the degree of distraction of the instruments possible, thus reducing the range of movement. Therefore the ideal port is a short but wide port that can stretch tissues to avoid the need for a large incision. Of course, if instruments are utilized in a crossed fashion, the requirement for a wide port to allow for triangulation is diminished

Third, the various devices have differences in their abdominal wall retention, with some devices slipping/displacing more easily than others. This will vary from operator to operator and will be down to personal preference. Finally, some devices allow for rotation of the access channels (e.g., TriPort+ port from Olympus or X-CONE from Storz) allowing the operator to change the internal instrument configuration easily.

SALS access devices also have other special features for consideration. The Storz ports are reusable (although the valves have a limited lifespan and may need replacement). Homemade surgical devices are more affordable. The TriPort+ port has the unique ability to compress the abdominal wall at the access site. This has the effect of reducing the depth and increasing the width of the access site, hence increasing the range of movement and capacity for triangulation, a feature that is particularly useful in obese patients. Another unique feature of the GelPOINT and TriPort+ ports is that the ability to insufflate into a soft-walled channel allows radial force to be applied to the channel, thus maintaining an air lock. The GelPOINT also allows for the insertion of any number of trocars or the surgeon's choice. The SILS port (Covidien) is a solid port and so results in fewer instrument clashes within the port, affording a greater degree of triangulation.

Access device insertion is unique to each port. For example, with the SILS port, the camera channel (if using a 10 mm laparoscope) needs to be the most inferior channel therefore deflecting the other channels upwards to avoid peritoneal puncture during a TEP inguinal hernia repair. The access strategies for each individual hernia repair will be discussed below.

In summary, the choice of ports needs to suit the surgeon, procedure, and patient. It is hard to be proscriptive. Multiple publications have supported the use of each individual device.

3.2.1.2 Vision

One of the most important decisions the surgeon must make in undertaking SALS is the choice of videolaparoscope, of which multiple designs are available. The size of the laparoscope will be a balance between the reduction in crowding at the access device afforded by the 5 mm laparoscopes and the increased light provided via a 10 mm laparoscope. Furthermore, long and short laparoscopes are available which allow surgeons to try and avoid external clashing with instruments depending on their choice of instrument. Videolaparoscopes can be either rigid rod designs, with 0–45° tips, or flexible tip laparoscopes (e.g., the Storz ENDOCAMELEON® and the Olympus ENDOEYE Flex 3D). Rigid laparoscopes are more familiar for camera operators but offer a more limited view than flexible tip laparoscopes. However, the surgeon must consider the suitability of an angled rod laparoscope or flexible tip laparoscope to each procedure. For instance, in performing TEP inguinal hernia repairs, there is often not enough space to adequately use an angled or flexible tip laparoscope without unduly increasing the dissected space.

Once a laparoscope has been selected, the camera operator must be adequately trained in SALS procedures to provide the correct balance between optimal vision and limited external clash with instruments. Here, the author would like to introduce the concept of "soft but hard" camera operation. In essence, the surgeon will define a set point for the camera operator to fix to, essentially the site of current dissection. If, in the course of performing the required maneuvers at that location, it is necessary for the surgeon to clash with the camera operator, he/she should allow the laparoscope to be deflected away from the set point on application of a certain amount of pressure from the surgeon but then rapidly return to the set point at the end of the maneuver. Familiarity between surgeon and camera operator facilitates this exercise. It is the author's experience that the challenges of SALS are amplified by novice camera operators. Therefore, establishing a single team for these procedures is essential.

3.2.1.3 Instruments

At the inception of SALS, new instruments were designed to compensate for the loss of triangulation that laparoscopic surgeons had become accustomed to. In general, these included rigid straight instruments, rigid curved instruments, and flexible instruments (which were single-use instruments). Economic considerations now influence the uptake of these instruments in SALS today.

A consideration common to all instruments is the size and shape of the handle, as well as the diathermy connection position. Ideally, a low profile handle will produce less hand clashes. Also, some types of handle ratchets may increase external clash (e.g., Manhes swing-away ratchet, Storz). Olympus has designed their handles to incorporate the diathermy lead connection to minimize external clash (HiQ LS series from Olympus). Rigid curved instruments may have a single curve or a double curve. It may be more appropriate to consider using a combination of straight and curved instruments to suit the procedure.

3.2.2 Technique

In general, the techniques of performing each type of hernia repair using the SALS approach are identical to those performed using multiple port laparoscopic procedures. There are a few general principles of SALS to consider.

1. The author would like to introduce the concept of instrument shadow (Fig. 3.2a). This concerns the loss of range of movement experienced when two instruments are inserted into a single port. Essentially, if one instrument is fixed in position, the range of movement of the second instrument will be limited by clashes with the fixed instrument. Therefore, changes in the angle between the two instruments will change the regions of inaccessibility by the active instrument – the instrument shadow. This effect alters if a rotating port is used. Furthermore, the instrument shadow will be increased by incremental advancement of the laparoscope (Fig. 3.2b). In a laboratory setting, we have found that a distance of at least 6 cm from the target is required to minimize instrument shadow. The instrument shadow can be further minimized by dynamic use of both instruments.
2. The author would advocate a "fly-by-wire" operating technique. Many surgeons try to analyze hand movements and maintain uncrossed instruments. A less frus-

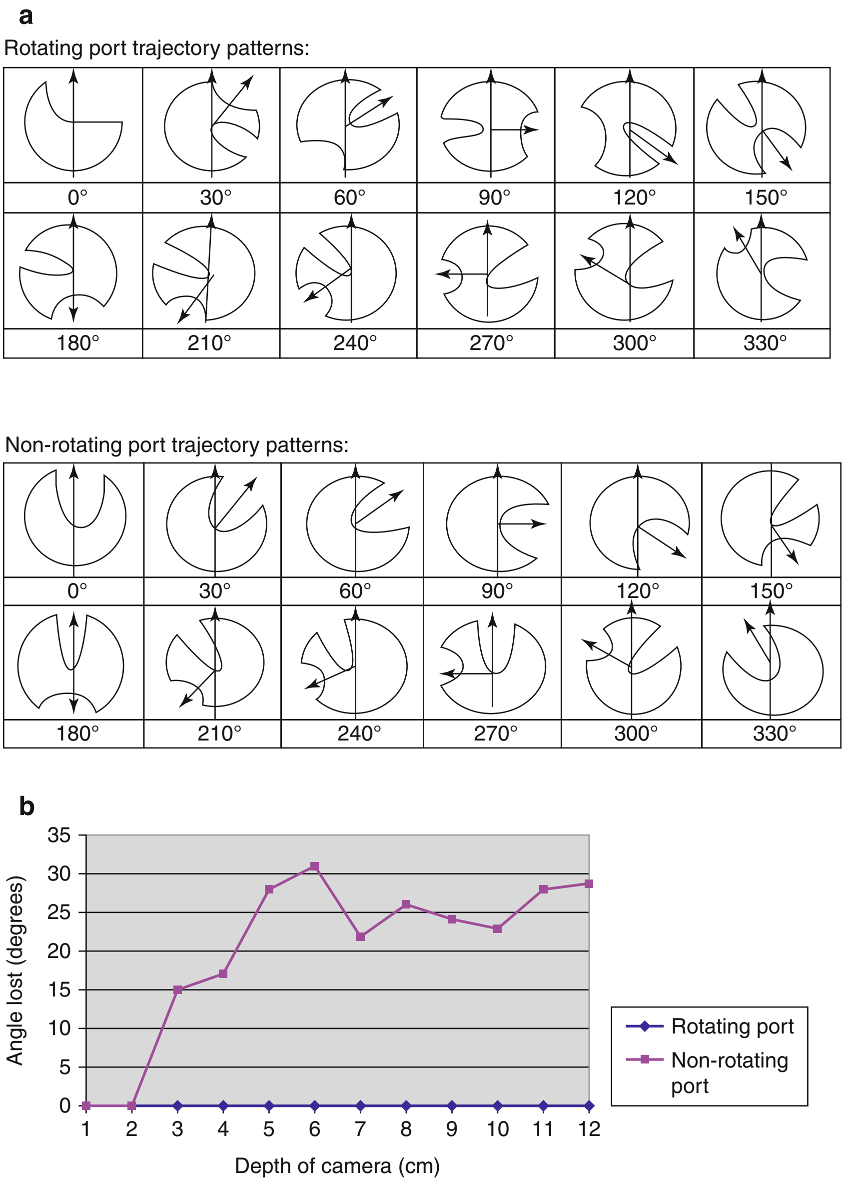

Fig. 3.2 The effect of instrument shadow in SALS procedures. (**a**) Using a fixed camera position and a fixed instrument, the positions that a second instrument can access is defined with varying angles between fixed instrument and camera. The resulting shadow varies depending not only on the angle but also on whether a rotating or nonrotating port is used. It should be noted that any shadow created using a rotating port is dynamic – that is, the shadow can be rotated to allow access to the "concealed" area without changing the angle of the instruments. (**b**) The further a laparoscope is advanced into the operative field (and so the closer it is to the objective), the more likely the camera is to behave as a third instrument. This will have the effect of introducing a new instrument shadow, thus reducing the degrees of movement available for the instruments. A minimum distance of 6 cm advancement of the laparoscope through the port is recommended to limit this effect

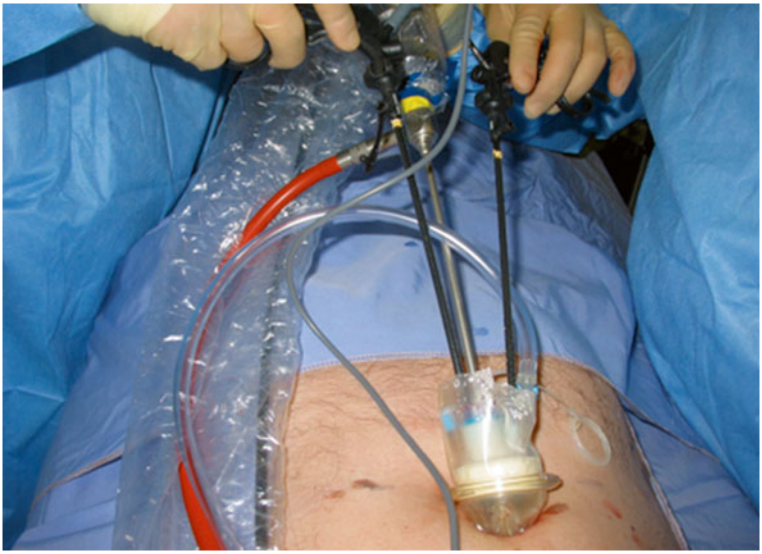

Fig. 3.3 Demonstration of the pronated hand position during a SALS TEP hernia repair. In this way, even "Manhes swing-away ratchet" can be kept out of the way and handle clashes minimized. This is particularly true if the up/down distraction technique is used. However, if diathermy leads are attached to the top of the instrument, this hand position will bring the lead into play, and consideration for low profile handles is encouraged

trating strategy would be to accept that instruments will cross and clash. Thus, the objective becomes to minimize the impact of clash but accept the cross. This can best be achieved by avoiding the micromanagement of each component of each maneuver. Rather, one should concentrate instead on the final goal and leave geometric calculations to the "subconscious brain," in a manner akin to robotics and modern aircraft design.

3. Many surgeons can perform surgical tasks equally well with both hands. However, if handedness is problematic in SALS (particularly when instruments are crossed), one strategy is to work with one instrument on top of the other. Movements are therefore up and down rather than left and right, making handedness issues redundant.
4. Strategies to reduce external clashing of handles include pronation of both hands (Fig. 3.3), changing lengths of instruments, or adjusting the assistant position.
5. Surgeons new to SALS should consider the procedures they undertake at the start of their learning curve. The simplest procedures to start with are appendectomies and paraumbilical hernia repairs. If TEP hernias are to be used as initial SALS procedures, an initial training phase could involve shortening the distance between the three ports in a conventional laparoscopic TEP to learn how to manage instrument clashes.
6. The dogma of the 2.5 cm incision for SALS port insertion is now largely defunct. The incision can be tailored first to the port used and can often be as small as

1.5 cm. In the personal series of 400 SALS TEP hernia repairs, the scar size varies between 8 and 40 mm (this includes the author's learning curve).

7. SALS ports have an inherent difficulty in smoke evacuation, as both insufflation and evacuation ports are at the same location. A better technique would be to collapse the space and re-insufflate fresh CO_2. If available, allowing a continuous air leak from the instrument cleaning channel is another option.
8. All SALS ports have air leak issues, and increasing the insufflation flow rate once the space is fully expanded may mitigate this.
9. If bleeding is problematic, it can smear the inside of the port (particularly the TriPort+ and the GelPort). In this case, tonsillar or small swabs can be used to wipe clean the interior of the port rather than its removal.

3.2.3 Groin Hernias

This category includes inguinal and femoral hernias. The author's personal series of over 400 patients (of which the first 102 are published [9]) was a natural progression from the standard three-port technique. Here, the limited space meant that progression to a SALS approach resulted in minimal changes in technique. A new SALS surgeon could develop his dissection technique by shortening the distance between the port positions in multiport TEP hernias, if using the three midline port technique. This is how the author started developing his technique. It was driven by necessity as the author found difficulty with the most inferior port clashing with the mesh. Therefore the conversion to SALS TEP hernia technique was simple.

There are a number of anecdotal advantages to this approach for groin hernias. By comparison to balloon-assisted dissection, direct visualization of the preperitoneal plane before starting dissection results in less bleeding. This is facilitated by the tenting open of the space by the retention mechanism of the SALS port. In comparison to published data, the author's own published series revealed a quicker return to activities of daily living and a surprising number of patients who needed no analgesia postoperatively facilitating quicker return to work and to sporting activities [9].

As a standard technique for TEP inguinal hernia repairs, the author uses a TriPort+ port. This is inserted through an intra-umbilical (within the umbilical ring, giving a favorable cosmetic result) 15 mm incision. The incision is then drawn downwards and laterally onto the anterior rectus sheath on the ipsilateral side. The retro-rectus dissection is similar to that performed with a normal balloon port. Care is taken to make the anterior rectus incision no larger than 15 mm, facilitating port retention. Digital manipulation of the retraction ring into the upright position is followed by retraction of the sheath to compress the abdominal wall. The boot of the port is then attached, placing the 10 mm port most inferior. Instruments are then inserted under direct vision. The standard TEP dissection is then employed, taking care only to apply diathermy to vessels that run across the dissection field but not along the anterior surface. The author uses two straight blunt dissectors and a 10 mm 0° laparoscope. It is crucial to ensure that there is sufficient lateral dissection up to the anterior superior iliac spine, but without drifting into the inter-muscular plane, therefore avoiding chronic pain.

The author uses a 15 cm round mesh to avoid orientation difficulties (personal correspondence from Wibo Weidema). In SALS TEP hernia repair, there is no problem with the inferior port clashing with the mesh. However there is a danger of placing the mesh too high on the abdominal wall. The center of the mesh is marked to ensure the mesh is centralized on the hernia orifice. As per the standard approach, gas is evacuated at the end of the procedure under direct vision to ensure correct mesh placement. At the end of the procedure, local anesthetic is injected into each rectus sheath above the incision, providing excellent analgesia. In the author's experience, >55 % of patients require no further analgesia postoperatively [9]. Immediate mobilization is encouraged, with some patients even attending the gym the next day. Femoral hernias are repaired using the same technique, ensuring the sac is fully reduced, including the extraperitoneal fat using bimanual reduction to avoid a residual groin lump.

3.2.4 Spigelian Hernias

The author uses a similar technique to the TEP inguinal hernia repair. The hernia occurs at the point where the linea semilunaris meets the arcuate line. Therefore, the author dissects cranially above the posterior rectus sheath at the lateral edge of the TEP dissection field. A 20 × 15 cm mesh is then placed covering the inguinal orifices up to and beyond the arcuate line, on to the posterior rectus sheath.

3.2.5 Ventral Hernias

Ventral hernia repairs are useful as an operation to train in SALS. This operation in a multiparous woman enables a large working space to be created. This allows for the training in cross instrument manipulation and clashing as well as familiarization between the surgeon and the assistant. Without the adhesions of an incisional hernia, it is a relatively simple operation.

Port placement for ventral hernias is preferentially performed through a 2 cm incision lateral to Palmer's point in the left flank, using a muscle splitting technique under direct vision. The incision size should match the diameter of the introducer. When using the TriPort+, the port should overlap the introducer by a few millimeters. This will allow for the port to protect internal structures from the introducer. If using other ports, care should be taken with port insertion. As discussed previously, it is not necessary to create a large incision. If the crossed hands technique (Fig. 3.1) is utilized, it is the depth of the tissue that will govern the degree of movement, not the diameter of the incision.

The operation is as for multiport hernia repair. The author will, if necessary, take down the falciform ligament to create space for the mesh overlap an epigastric hernia. The hernia sac is excised following inversion. An appropriately sized (5 cm overlap at minimum) Parietex composite PCOx mesh (Covidien) is the author's preferred device. The mesh is inserted through the port, which is easier than through a standard port. The mesh is rolled with the composite membrane facing the inside of the roll to protect it. Initially, the author advocated a double crown of tacks to secure the mesh, centered over the defect, using absorbable tacks (e.g., Ethicon SecureStrap). There is preliminary data suggesting that absorbable tacks produce less postoperative pain that titanium tacks [10] following ventral hernia repairs. Now, anecdotal experience suggests the inner crown may (i) not be required for reduction of hernia recurrence, (ii) even increase postoperative pain, and (iii) prevent uniform tension distribution through the mesh (personal communication Michel Therin, vice president New Product Development, Covidien Surgical Solutions). As per normal multiport operations, the tack distance between each tack is 1–1.5 cm. Patients are warned to expect seromas in the hernia sac space postoperatively, and these are not routinely aspirated.

In very young patients since 2009, the author prefers to avoid the use of mesh in the repair and now performs a SALS-assisted suture plication using the Endo Close device, Covidien, with a heavy nonabsorbable suture. The SALS port is used in the umbilicus with a trans-umbilical incision. This creates an "invisible" scar. Through the port the falciform ligament is cleared, and using an Endo Close device (Covidien), a suture is passed from externally through a single puncture in the skin through the intraperitoneal space cranially to the hernial defect. Then through the same skin puncture, the suture is grasped caudally and brought out through the same skin defect. Both ends are then ligated and the knot dropped into the subcutaneous tissue. The same skin puncture can be used for two similar sutures before a new puncture is required. This technique is useful for smaller defects. It provides an elegant solution for patients who are scar averse.

3.2.6 Incisional Hernias

Incisional hernias are the most difficult of all the SALS hernia repairs. The author feels that the dissection of the bowels off the anterior abdominal wall requires significant dexterity and practice to avoid inadvertent injury during adhesiolysis. I would recommend that any practitioner begin with handling bowel in appendectomies and getting used to "running the bowel" with a SALS technique. It is possible to practice in a dry laboratory handling and passing string competently before trying to repair incisional hernias with SALS.

The technique for repair of ventral incisional hernias is essentially identical to that of primary ventral hernias, with some obvious exceptions. First, if the hernia is on the left side of the abdomen, clearly the first port position must be switched to the contralateral side. Second, there is an intermediate step of adhesiolysis to create a space for the mesh before the mesh is introduced. The main advantage of the

SALS approach to incisional ventral hernia repair over standard multiport laparoscopic repairs is that if insertion of the first port is successful, there is no requirement for a further space to insert instrument ports following this. Adhesiolysis can commence directly from the port site if necessary.

Conclusions

The role of the laparoscopic approach to repair of abdominal wall hernias has been well established, with advantages over open surgery including less pain and quicker return to daily activities coupled with equivalence in morbidity and recurrence rates. In adopting a SALS approach to the laparoscopic approach, there are a number of technical aspects to consider and new equipment to appraise. In some cases there are clear advantages (e.g., incisional [11, 12], ventral [12–14] and inguinal hernia repairs [15, 16]), while in the most part, there is insufficient data to declare true equivalence between SALS and multiport laparoscopic approaches. Some studies suggest the port site hernia rate after SALS procedures (varied) is higher than for standard laparoscopic procedures [17], and thus care must be taken to close the incisions. The author uses "1 PDS" sutures for closure. The advantage with single-port surgery is that, if larger incisions are used, there is increased visualization of the appropriate fascial layers for accurate approximation. However, the cohort sizes are very small, and there is no uniformity in technique in terms of port use and insertion technique at this time. Therefore no conclusions about this can be drawn at this time. However, the author's own experience is that SALS port site hernias occur at an equivalent incidence to standard laparoscopic port site hernias if incisions <2 cm are used.

The most important advice the author can conclude this chapter with is for the prospective SALS surgeon to develop the required skills in a controlled and safe environment. Attending courses, laboratory practice, attending live operations, and mentorship are important steps in the process of developing the technique carefully and safely, thus protecting patients during the learning curve.

References

1. Basile F, Biondi A, Donati M (2013) Surgical approach to abdominal wall defects: history and new trends. Int J Surg 11(Suppl 1):S20–S23
2. McCormack K et al (2003) Laparoscopic techniques versus open techniques for inguinal hernia repair. Cochrane Database Syst Rev (1):CD001785
3. Davis CJ, Arregui ME (2003) Laparoscopic repair for groin hernias. Surg Clin North Am 83(5):1141–1161
4. Simons MP et al (2009) European Hernia Society guidelines on the treatment of inguinal hernia in adult patients. Hernia 13(4):343–403
5. Kapischke M et al (2008) Open versus laparoscopic incisional hernia repair: something different from a meta-analysis. Surg Endosc 22(10):2251–2260
6. Sauerland S et al (2011) Laparoscopic versus open surgical techniques for ventral or incisional hernia repair. Cochrane Database Syst Rev (3):CD007781
7. Forbes SS et al (2009) Meta-analysis of randomized controlled trials comparing open and laparoscopic ventral and incisional hernia repair with mesh. Br J Surg 96(8):851–858

8. Sajid MS et al (2009) Laparoscopic versus open repair of incisional/ventral hernia: a meta-analysis. Am J Surg 197(1):64–72
9. Soon Y et al (2012) Single-port hernia repair: a prospective cohort of 102 patients. Hernia 16(4):393–396
10. Cavallaro G et al (2013) Lightweight polypropylene mesh fixation in laparoscopic incisional hernia repair. Minim Invasive Ther Allied Technol 22(5):283–287
11. Tsivian A, Tsivian M, Sidi AA (2011) Laparoendoscopic single-site repair of incisional hernias after urological surgery. Urology 78(3):715–718
12. Bucher P, Pugin F, Morel P (2011) Single-port access prosthetic repair for primary and incisional ventral hernia: toward less parietal trauma. Surg Endosc 25(6):1921–1925
13. Gronvold LB et al (2012) Single-incision laparoscopic versus conventional laparoscopic ventral hernia repair: a comparison of short-term surgical results. Surg Laparosc Endosc Percutan Tech 22(4):354–357
14. Bower CE, Love KM (2011) Single incision laparoscopic ventral hernia repair. JSLS 15(2):165–168
15. Yussra Y et al (2013) Single incision laparoscopic surgery (SILS) inguinal hernia repair – recent clinical experiences of this novel technique. Clin Ter 164(5):425–428
16. Buckley FP 3rd et al (2014) Comparison of outcomes for single-incision laparoscopic inguinal herniorrhaphy and traditional three-port laparoscopic herniorrhaphy at a single institution. Surg Endosc 28(1):30–35
17. Alptekin H et al (2012) Incisional hernia rate may increase after single-port cholecystectomy. J Laparoendosc Adv Surg Tech A 22(8):731–737

4 Single Access Laparoscopic Cholecystectomy

Marco Maria Lirici and Cecilia Ponzano

Twenty-five years ago, the introduction of laparoscopy revolutionized surgery, the main reason for its widespread diffusion being the following patient's benefits: less postoperative pain, faster recovery, better cosmetics, and quicker return to full activities, all resulting in the improvement of postoperative quality of life.

Actually, the aforementioned benefits have never been demonstrated in randomized controlled trial for laparoscopic cholecystectomy. Despite this lack of evidence, laparoscopic cholecystectomy has been accepted and is nowadays considered as the gold standard treatment of gallstones.

Also, some of the advantages of laparoscopy are ascribable to reduced abdominal wall trauma, which led both to reduced incidence of surgical site infections and, in the long term, to reduced occurrence of incisional hernia.

Over the last decade new efforts have been made to further reduce abdominal wall trauma, introducing innovative minimally invasive techniques. Among those, natural orifice transluminal endoscopic surgery (NOTES) is a challenging technique, still lacks appropriate instrumentation, and has the disadvantage of requiring the closure of the access to the peritoneal cavity. Furthermore, NOTES approach to cholecystectomy requires an access through internal viscera or structures that have no direct relations to the targeted organ, thus posing ethical issues and criticisms [1].

The other new technique, which uses the umbilicus as a natural orifice allowing easy access to peritoneal cavity, easy conversion to standard laparoscopy, and its easy closure, has been widely introduced into the clinical practice. Much has been

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_4, © Springer International Publishing Switzerland 2014

reported in the literature on single site approaches to all the most common operations. Most likely, the development of these procedures has been partially supported by strong commercial marketing and publication competition [2], but the real clinical benefits for patients still remain a matter of debate. In the last 3 years, many randomized trials and meta-analyses on single access laparoscopic cholecystectomy (SALC) have been published, trying to answer the question whether such a new approach is worthwhile or not and whether it is safe and cost-effective.

The way to look at the single access approach to gallbladder removal and any analysis of reported data should not forget the followings:

On one side, the excessive criticism against laparoscopic cholecystectomy when such a new technique was introduced at the end of the 1980s, avoiding a short-sighted vision of new technique and technology applications to surgery.

On the other side, the fear that, as happened with the widespread diffusion of laparoscopic cholecystectomy in the early 1990s, a significant increase in the overall complication rate could occur as a result of learning curve and impaired visualization or exposure essential to achieve the "critical view of safety" of Calot's triangle. This theoretical risk of an augmented morbidity must be kept in mind when evaluating a technique, the major benefit of which seems to be improved cosmetics [3, 4].

4.1 Indications

As from the results of most RCTs and systematic reviews, the single access approach to laparoscopic cholecystectomy is mainly indicated in patients with BMI <30/35 kg/m^2, thus excluding severe and morbid obese patients. Further contraindications to SALC are acute cholecystitis and all the so-called difficult cholecystectomies (patients with a Nassar score or an adhesions score III or IV) [5]. Previous surgery on the upper abdomen may be a relative contraindication. In all cases where predictive indexes of difficult cholecystectomy are unclear [6], the procedure may start with a single access approach to exploration and possibly be converted to standard laparoscopy. Routine or a la demande intraoperative cholangiography is not a contraindication to the single access approach [7].

4.2 Technologies and Surgical Technique

4.2.1 Access, Access Devices, and Instruments

The access site for SALC is always the navel. SALC may be carried out through disposable devices, reusable devices, or a multiple fascia puncture technique (Swiss cheese technique). Among disposable devices, foam devices (i.e., SILS®) require the use of a retrieval bag for gallbladder withdrawal; when 2-component devices with abdominal wall protection sleeves (i.e., TriPort®, GelPort®) are used, there is no need for retrieval bags to withdraw the gallbladder. Reusable devices like the Storz X-cone® and Endo-cone® allow the insertion of more instruments from different angles of direction (also necessary to overcome lack of flexibility), require a

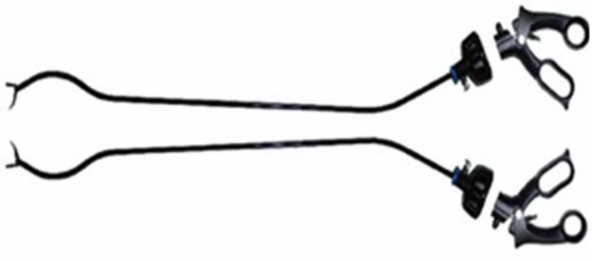

Fig. 4.1 Pre-shaped curved instruments reproduce open surgery triangulation

Fig. 4.2 5-mm chip-on-the-tip scopes reduce encumbrance within the access device

longer skin and fascia incision, and entail the need for a retrieval bag for gallbladder removal.

When a multiple fascia puncture technique is preferred, at the end of the operation, two of the fascia openings are connected with a small incision to allow the passage of the retrieval bag and gallbladder withdrawal.

SALC may be accomplished by standard straight laparoscopic instruments or pre-shaped curved instruments (Fig. 4.1). In both cases, instruments are reusable; the latter allow triangulation within the operative field. SALC should be carried out preferably under the guidance of 5-mm 30° scopes connected to a high-definition imaging system (Fig. 4.2). Dedicated scopes, either those longer than the standard ones or the chip-on-the-tip 5-mm EndoEYE® video-endoscope (Olympus) (Fig. 4.3), enhance vision during single access laparoscopic procedures.

4.2.2 Dissection Technologies

Tissue dissection during SALC may be accomplished either by monopolar HF or by US devices. The authors believe that HF hooks should be preferred to HF energized scissors: hooking up tissues and their tenting before applying energy is of utmost relevance when traction and movement freedom are impaired, making the dissection safer . Ultrasonic dissection provides an almost bloodless field, preventing

Fig. 4.3 Articulated scopes allow better inside view without collision with the working instruments and between operator and camera assistant's hands

Fig. 4.4 Appearance of the skin incision at the end of SALC

oozing from tissue division. Unfortunately, the use of disposable US shears increases costs considerably.

4.2.3 Surgical Technique

The patient lays legs apart in supine position, with the surgeon standing between the legs (French position) and the assistant on the patient's left side.

Access to the peritoneal cavity is obtained through a skin incision of about 15–20 mm either right around the upper edge of the umbilicus as in most CLC (Fig. 4.4) or dividing longitudinally the umbilicus itself. In the latter case, the umbilicus is grasped at its base everted. The skin incision is made within the umbilical fold and an approximately 20-mm fascia incision is created to allow the introduction of the single site access device. Pneumoperitoneum is then established. Three instruments are generally introduced through the single access device: a 5-mm 30° scope and two 5-mm working instruments. Those instruments, a grasper and an energized device, can be straight or curved (Fig. 4.5). Ten-millimeter optics may be used as well, but this will further reduce the working room and instrument handling.

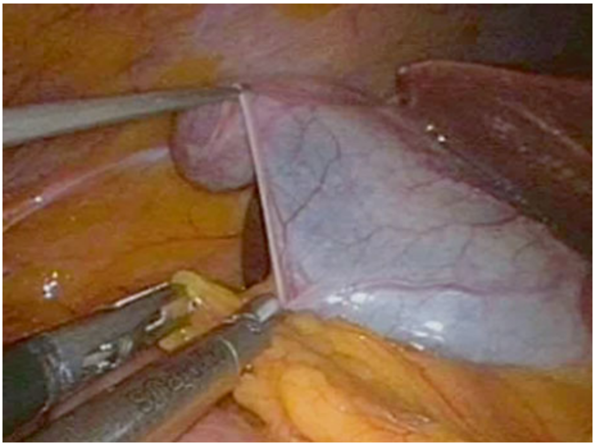

Fig. 4.5 Grasping and dissection instruments have an almost parallel direction within the operating field. The TriPort® and Quad-port® (Olympus) devices allow the passage of a further 1.8-mm grasper that enhances traction, thus improving exposure

Exploration of the supramesocolic space and the operating field is carried out first, checking the gallbladder and the possibility to achieve a good exposure of the Calot's triangle.

Gallbladder dissection is accomplished either after preparation of the cystic duct and artery or with a fundus-first technique, by high-frequency hook/scissors or ultrasonic shears.

When straight instruments are employed, the one in the right hand is used to retract the gallbladder ampulla to the right and cephalad.

The Calot's triangle is dissected with the left-hand instrument in order to achieve the Strasberg critical view of safety visualizing and dissecting free the cystic duct and artery. In such a case, the working instruments cross, and there is never the possibility to achieve optimal instrument triangulation within the operative field. The cystic artery is either divided between clips or closed and divided by ultrasonic shears, whereas the duct is preferably secured with titanium or absorbable clips (Fig. 4.6). Use of 5-mm-diameter disposable clip appliers is advised. Even though cystic ducts larger less than 5 mm in diameter may be closed-divided by ultrasonic shears, thus reducing need for instrument exchange, division of the duct by US energy was never performed within RCTs in order to avoid possible bias. Gallbladder dissection from the gallbladder fossa is accomplished in the usual manner, and the specimen is removed with a retrieval bag or through the access device, thus avoiding abdominal wall contamination. In case of larger stones, gallbladder extraction through the access device may be laborious and time consuming, and an extension of the parietal incision may be required.

When the fundus-first technique is carried out, the gallbladder should be dissected preferably by ultrasonically activated shears, thus avoiding oozing due to not performing prior cystic artery ligature. With this technique, once the gallbladder is fully mobilized, traction on the infundibulum is improved, allowing a better visualization of the Calot's triangle and identification of anatomical structures and an easier dissection of cystic artery and duct. Nevertheless, during fundus-first dissection, maximum care should be taken while approaching the infundibulum, in order to avoid injuries to hidden posterior structures.

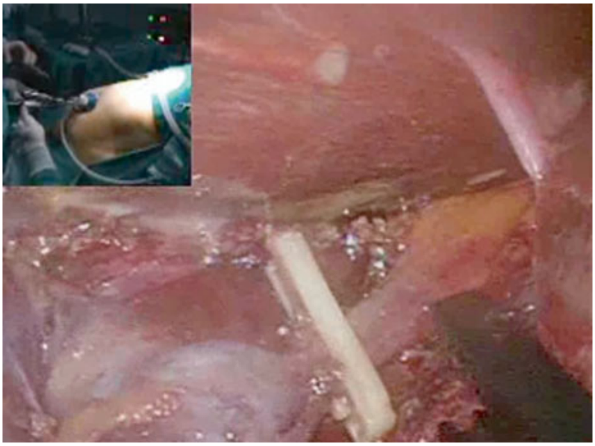

Fig. 4.6 An absorbable clip is applied on the cystic duct before its division by ultrasonic shears

In authors' view, the optimal instrument combination to accomplish SALC safely and faster is achieved by using one pre-shaped curved instrument for grasping and one straight instrument for dissection (either US scissors or HF hook). Not only curved graspers may be kept outside the operating field while retracting the gallbladder, also their bent part may be used for gentle liver traction without risk of injuries. Furthermore, straight dissection instruments are easily guided within the operating field, and the combined use of pre-shaped curved instruments and straight instruments, which are usually different in length, decreases surgeon's hand conflict.

A further 5-mm cannula may be placed on the upper left quadrant to introduce a fourth instrument, thus enhancing exposure or dissection: in such a case the operation should be considered as converted to reduced port laparoscopy.

At the end of the procedure, the fascia incision should be carefully closed, to minimize incisional hernia occurrence. Compared to the closure of laparoscopic incisions after CLC, fascial suture through the wider skin incision of SALC should be theoretically easier; nevertheless, this seems not to have any positive effect on the incidence of incisional hernia.

4.3 Drawbacks, Tips and Tricks, and Technical Variations

Reduced degrees of freedom of working instruments, lack of triangulation, poor working room, and fencing effect of instruments that have an almost parallel direction when introduced through a single access device are the limits of single access laparoscopy. During SALC, these limits entail three major drawbacks: restrained instrument movements, poor traction, and insufficient exposure. The latter is mainly caused by the difficulty in providing optimal liver retraction, especially when straight instruments are used: their direction within the operating field does not allow lifting up the inferior aspect of the liver without puncturing or tearing the parenchyma.

View may be compromised by in-line viewing, caused by both the proximity of optic and working instruments and lack of an optimal angle of view. This may affect surgical judgment and depth perception and reduces view of target tissues as well. Furthermore, standard length, straight telescopes, and working instruments may hamper each other, when handled. The same may happen with the hands of the two surgeons.

While working with straight instruments, the surgeon must learn to operate on a mirror image because the right hand is controlling the left-sided instrument on the screen and vice versa.

Traction and improved exposure may be achieved by transfixing stay sutures or internal retractors. A monofilament nylon suture with straight needle is passed through the abdominal wall right below the costal arch, passed through the fundus, hence back through the abdominal wall to suspend the gallbladder by anchoring it to the wall. A second stay suture may be passed in similar fashion through the infundibulum to provide lateral traction, thus achieving a wider opening of Calot's triangle. The EndoGrab® is a small 2-component internal retractor featuring springs and hooks that may be introduced through the access device, used to make traction by anchoring tissues, with ease to be replaced according to the surgeon's needs [8]. One component is used to grab the fundus; the second component's hook is used to hang the gallbladder up to the wall. In Authors' opinion, internal retractors should be preferred: use of stay sutures in some way contravenes the principle of mobile exposure, by preventing the surgeon from moving the Hartmann's pouch while attempting to expose the Calot's triangle. Other authors argue that transfixing sutures also increase risk of gallbladder perforation, an event that may cause bile spillage, often associated with pain (due to peritoneal irritation and inflammation) and potential postoperative infections. Nevertheless, there is no evidence that stay sutures increase postoperative morbidity after SALC.

Telescopes with articulating tips and bent instruments help in minimizing conflict during surgical maneuvers and enhance visualization of the operative field. Use of instruments different in length may prevent hand conflict [9]. A further physical constraint encountered during SALC is the frequent interference of the light cable with other instruments: use of optical systems with light cable connection located on their head is advised whenever possible.

A wider incision allows more freedom in instrument handling, which is particularly useful when straight instruments are used to carry out the operation. Lirici et al. demonstrated a correlation between operating time and umbilical incision length: the wider the incision, the less the operating time [1].

4.3.1 SALC-POP (Plus One Port) Technique

Kanehira (personal report, 2010) proposed the use of one needlescopic grasper (1.8–3 mm in diameter) to provide a clearer view of the operative field, instrument triangulation, and faster dissection or coagulation when bleeding occurs, a technique that may be applied also to accomplish other single access procedures [10]. Present needlescopic and minilaparoscopy graspers are nitinol or surgical steel instruments with good grasping capability. A needlescopic grasper is introduced through the upper left quadrant of the abdomen with an optimal working angle. Its insertion does not require the placement of a cannula and is not considered a conversion to reduced port laparoscopy.

4.3.2 Single Access Robotic Cholecystectomy

The introduction of the novel da Vinci® robotic single-port platform allows performing SALC overcoming most of its limits, relating to instrument triangulation, ergonomics, and surgical exposure. The single-port platform elaborates the images giving the surgeon the feeling of not performing surgery on a mirror image while working with straight instruments that cross within the operative field. Results from a prospective longitudinal observational study conducted on 100 consecutive da Vinci single access cholecystectomies [11] with feasibility without conversion and safety as primary end point showed that the robotic approach is safe and allows a quicker overcoming of the learning curve phase. Conversion rate was minimal with mean total operating time of 72 min and console time of 32 min. Nevertheless, operating time does not decrease by increasing surgeon's experience. After subjective evaluation through a questionnaire collecting surgeons' opinions, single access robotic cholecystectomy was judged more complex than CLC but easier then manual SALC.

4.4 The Evidence

Since 2010 several randomized trials [1, 9–23], meta-analyses [24–27], and systematic review [28] comparing single access laparoscopic cholecystectomy (SALC) and conventional laparoscopic cholecystectomy (CLC) have been published with the following end points: feasibility and safety, pain scores, cosmetics, satisfaction scores, and quality of life. Details of patient study groups and interventions from 14 randomized trials are shown in Table 4.1. In all studies but one, [14] acute cholecystitis was considered an exclusion criterion.

Body mass index ≥30 kg/m^2 was an exclusion criterion in five studies [1, 15, 19, 20, 23], ≥40 kg/m^2 in three [9, 17, 21], and ≥45 kg/m^2 in one [13]. In four studies a high BMI value was not considered an exclusion criterion, but despite this, the mean BMI of those studies never exceeds 30 kg/m^2 [14, 16, 18, 22].

Pain score was the primary end point in nine studies [1, 9, 14, 17–19, 21–23], cosmetic results in three [1, 14, 16], and operative time and safety each in one [12, 13]. Primary end points were not clearly expressed in two [15, 20].

Mortality and morbidity rates and operating time were secondary end points in all studies but one [23].

In 11 out of 14 studies, operating time was significantly longer in the study group. SALC lasted an average of 20 min more than CLC. Postoperative length of stay did not differ significantly in both patient groups, nor was the mortality rate, which was 0 in all studies (Table 4.2). Morbidity rate was similar in both groups, as was the incidence of bile duct injuries. However, despite this lack of significance, the overall incidence of adverse effects was a little higher in SALC group, with a pooled OR of 1.15 (95 % CI 0.740–1.827), 1.21 (95 % CI 0.83–1.76), and 1.21 (95 % CI 0.73–2.01) as respectively reported in Pisanu, Hao, and Garg meta-analyses.

Wound complication rates were found higher in SALC group probably caused by heavier trauma to the umbilical site (4.53 % vs. 1 % [28], 11.7 % vs. 4.9 % [13]). Despite these data the largest consecutive series of patients undergoing single access laparoscopic procedures published in 2013 showed that the incidence of wound complications in these patients is acceptably low and is further reduced once the learning curve is over [29]. Factors associated with wound complications are higher body mass index, longer skin incision, and Swiss cheese (multi-puncture) technique [29].

In Marks et al. study – the published trial with the longest follow-up (1 year) – a statistically significant difference in postoperative hernia rates is also reported: 8.4 % in SALC patients vs. 1.2 % in CLC patients ($p = 0.03$). Reduced postoperative pain is one of the expected outcomes of SALC compared with CLC, but this point is still controversial. Pain scores were reported at different time intervals in 12 out of 14 studies (Table 4.3): postoperative pain was significantly worse in SALC patients in four studies [1, 13, 17, 18] and in CLC patients in four studies [15, 16, 22, 23], while in the remnant four studies, no differences in pain scores were found [9, 19–21]. The study from Ostlie et al. did not measure pain scores but the total dose of required analgesics: the authors found a trend toward a more frequent (even though not significant) administration of pain-relieving medications in SALC group. Also all meta-analyses [24–27] failed to find a statistically significant difference in pain scores.

Data on satisfaction for postoperative cosmetics were significantly better for SALC patients in all studies but one [17] (Table 4.4), and this result was highlighted in all meta-analyses and systematic review [24–28]. However, it is not clear whether such an advantage may lead to better quality of life. In fact, data on postoperative quality of life are significantly better in SALC patients in four studies [1, 16, 19, 21], whereas are worst in one [13]. This may be possibly a direct consequence of the higher incidence of wound complications registered in the latter study (Table 4.4). Zehetner's meta-analysis, which is the only one carried out to assess quality of life, failed to find a significant difference in QoL between SALC and CLC.

4.5 Comments

Each new surgical technique introduced into the clinical practice must be compared to the gold standard technique before acceptance and consequent widespread diffusion. When laparoscopic surgery was introduced in the early 1990s, the scientific community raised many concerns on feasibility and safety, and, despite the

Table 4.1 Details of patients study groups and interventions from 14 RCTs

Authors	Inclusion criteria	Exclusion criteria	Primary end point	Operation	Study group				Control group			
					Sample size	Sex ratio (F/M)	Mean age	Mean BMI	Sample size	Sex ratio (F/M)	Mean age	Mean BMI
Ostlie et al. 2013 [12]	Age <18 scheduled for elective cholecystectomy	Cholecystitis weight >100 kg	Operative time	SALC (SILS Port, Covidien) vs. CLC (4-port)	30	8/2	14+−3.2	nr	30	8/2	13.3 + −3.3	nr
Marks et al. 2013 [13]	Age 18–85, BMI <45, gallstones, polyps, biliary dyskinesia with an ejection fraction <30 %	Pregnancy, acute cholecystitis, previous right subcostal or upper midline incision, preoperative indication for ERCP or for intraoperative biliary imaging, ASA >3, peritoneal dialysis, presence of umbilical hernia, previous umbilical hernia repair	Safety	SALC (SILS Port, Covidien) vs. CLC (4-port)	119	91/28	45.8	29	81	57/24	44	30.9
Leung et al. 2012 [14]	Age >18 years old, any patients with an indication for cholecystectomy	Pregnancy, <18 years old, porcelain gallbladder	Cosmesis Pain scores	SALC (device not reported) vs. CLC	36	*86.7 %F	41.8	28.7	43	*61%F	52.3	28.4

Zheng et al. 2012 [15]	Age >18, BMI <28, no significant comorbidities, cholelithiasis or polyps	Jaundice, suspected or verified stones in the CBD, acute cholecystitis, perforation of the gallbladder, previous abdominal operations	Unclear	SALC (ASC TriPort) vs. CLC (3-port)	30	17/13	43.6	24.7	30	14/16	46.8	25.9
Sinan et al. 2012 [9]	Cholelithiasis or polyps, no previous upper gastrointestinal surgery, BMI <40	Acute cholecystitis, pancreatitis, BMI >40, previous upper gastrointestinal surgery	Pain scores	SALC (SILS port, Covidien) vs. CLC	17	13/4	48.5	27.3	17	9/8	48.7	27.2
Lirici et al. 2011 [1]	Age 18–75, BMI ≤30, no previous upper GI surgery, gallstones, ASA ≤3, Nassar grades I–III	BMI >30, previous upper GI surgery per right colonic surgery, acute cholecystitis, bile duct stones, pancreatitis, ASA >3, Nassar grade IV	QoL (LoS, pain scores, cosmetic results, SF-36)	SALC (TriPort, Olympus) vs. CLC (4-port)	20	14/6	45	25	20	14/6	50	27
Asakuma et al. 2011 [22]	Age 20–85, clinically benign gallbladder disease	CBD stones, previous upper abdominal surgery, emergency presentation	Pain scores (VAS) Postoperative analgesic use	SALC (surgical glove port) vs. CLC (4-port)	24	13/11	57	24	25	12/13	66	24.1

(continued)

Table 4.1 (continued)

Authors	Inclusion criteria	Exclusion criteria	Primary end point	Operation	Study group: Sample size	Study group: Sex ratio (F/M)	Study group: Mean age	Study group: Mean BMI	Control group: Sample size	Control group: Sex ratio (F/M)	Control group: Mean age	Control group: Mean BMI
Ma et al. 2011 [17]	Age 18–85, gallstones, polyps, biliary dyskinesia, BMI <40, creatinine <2 mg/dL, AST/ALT <5× upper limit of laboratory normal	Choledocholithiasis, acute cholecystitis, gallstones >2.5 cm in greatest diameter	Pain scores (VAS)	SALC (ASC TriPort) vs. multi-incision (4-port)	21	nr	57.3**	28.2	21	Nr	45.8**	30.7
Aprea et al. 2011 [19]	Clinical symptoms and EUS evidence of gallstones	Previous abdominal surgery, signs of acute cholecystitis or choledocholithiasis or acute pancreatitis, ASA ≤3, BMI >30	Unclear	SALC (TriPort, Olympus) vs. CLC (3-port)	25	16/14	45.5	25.9	25	19/6	44.0	23.7
Cao et al. 2011 [20]	No sign of acute choledocholithiasis or acute pancreatitis, no epigastric surgery, ASA <3, age <70, BMI <30		Unclear	3 separate ports placed through the same umbilical incision, through separate fascial incisions vs. CLC (3-port)	57	34/23	62.2	28.6	51	29/22	59.7	29.1

Bucher et al. 2011 [16]	Elective patients with symptomatic gallbladder stones, history of cholecystitis, history of common bile duct stone migration and/or biliary pancreatitis, age >18	Acute gallbladder disease, contraindications to pneumoperitoneum, cirrhosis, mental impairment	Cosmetic result	SALC (ASC TriPort) vs. CLC (4-port)	75	nr	42	26	75	Nr	44	25
Lai et al. 2011 [18]	Age 18–80, symptomatic gallstones or gallbladder polyps	ASA IV or V, contraindication for laparoscopy, Mirizzi syndrome, suspected CBD stones, suspected malignancy, previous upper abdominal surgery, patients on long-term anticoagulant treatment, previous history of cholangitis or cholecystitis, gallstone > 3 cm, imaging diagnosis of contracted gallbladder or chronic cholecystitis	Pain scores	SALC (SILS port, Covidien) vs. CLC (4-port)	24	16/8	51.7	25	27	16/11	54.3	24.4

(continued)

Table 4.1 (continued)

					Study group				Control group			
Authors	Inclusion criteria	Exclusion criteria	Primary end point	Operation	Sample size	Sex ratio (F/M)	Mean age	Mean BMI	Sample size	Sex ratio (F/M)	Mean age	Mean BMI
Tsimoyiannis et al. 2010 [23]	BMI <30, cholelithiasis, ASA 1–2	BMI >30, sign of acute cholecystitis or attacks of acute pancreatitis, ASA >2	Pain scores	SALC (3 separate ports placed through the same umbilical incision, through separate fascial incisions) vs. CLC (4-port)	20	15/5	49.2	nr	20	19/1	47.9	nr
Lee et al. 2010 [21]	Symptomatic cholelithiasis, ASA 1–2	Acute cholecystitis, clinical evidence of CBD stones, severe obesity, previous upper abdominal surgery	Pain scores	SALC (Quad-port, LAGIS) vs. multi-incision minilaparoscopic (5-port)	35	22/13	51	24.2	35	20/15	53.3	25.8

nr not reported
*p 0.045; **p 0.01

Table 4.2 Operative time, conversion, morbidity and mortality rate, and lenght of stay in 14 RCTs

	Intervention group					Control group				
Authors	Operative time	Postoperative length of stay	Morbidity rate (%)	Conversion to open surgery/to conventional LC (%)	Mortality rate	Operative time	Postoperative length of stay	Morbidity rate %	Conversion to open surgery (%)	Mortality rate
Ostlie et al. 2013 [12]	68.6 ± 22.1*	1.01 ± 0.54 days	0	0	0	56.1 ± 22.1*	0.90 ± 0.12 days	0	0	0
Marks et al. 2013 [13]	56.8**	nr	45	0.84/0	0	45.3 **	nr	36		0
Leung et al. 2012 [14]	72.9***	27 h	0	13.8/0	0	46.2***	20 h	0	0	0
Zheng et al. 2012 [15]	55.6 ± 25.7****	3.7 ± 1.3	6.6	6.6/0	0	42.7 ± 18.6****	3.8 ± 0.8	3.3	0	0
Sinan et al. 2012 [9]	124.4 ± 29.7+	nr	5.9	nr	0	64.1 ± 26.1+	nr	5.9	nr	0
Lirici et al. 2011 [1]	76.75++	2.5	5.0	10/0	0	48.25++	2.65	15	5	0
Asakuma et al. 2011 [22]	110	3	0	0/4.1	0	100	3	0	8	0
Ma et al. 2011 [17]	88.5+++	nr	28.5	66.6/0	0	44.8+++	nr	19	0	0
Aprea et al. 2011 [19]	41.3 ± 12.0@	1.2 ± 0.4	0	8/0	0	35.6 ± 5.8@	1.16 ± 0.37	0	0	0
Cao et al. 2011 [20]	55.2 ± 12.4	2.1	3.5	nr	0	46.3 ± 10.8	2.8	1.9	nr	0
Bucher et al. 2011 [16]	66	0@@	4	2.6/0	0	64	1@@	5.3	0	0

(continued)

Table 4.2 (continued)

	Intervention group					Control group				
Authors	Operative time	Postoperative length of stay	Morbidity rate (%)	Conversion to open surgery/to conventional LC (%)	Mortality rate	Operative time	Postoperative length of stay	Morbidity rate %	Conversion to open surgery (%)	Mortality rate
Lai et al. 2011 [18]	43.5 ± 15.4	1.5±6	0	0/0	0	46.5 ± 20.1	1.8 ± 1.2	3.7	0	0
Tsimoyiannis et al. 2010 [23]	49.65 ± 9.02@@@	1.25±0.44	nr	nr	0	37.3 ± 9.16@@@	1.10 ± 0.44	nr	nr	0
Lee et al. 2010 [21]	71.7$	2.4$$	20	5.7/0	0	48.4$	2.9$$	14.2	0	0

nr not reported
*p 0.03; **$p < 0.0001$; ***$p = 0.0002$; ****$p = 0.03$; +$p < 0.001$; ++$p < 0.0001$; +++$p < 0.001$; @$p = 0.04$; @@$p = 0.014$; @@@$p < 0.0001$; $\$p < 0.001$; $\$\$p = 0.002$

Table 4.3 Postoperative pain

Marks et al. 2013 [13]	Before procedure	Before discharge	Day 1	Day 2	Day 5	Day 7	Day 14	Day 30
SILC	2.5	4.8	5.0	4.0	3.2	2.7	1.6	1.6
4PLC	2.5	4.5	4.4	3.3	2.5	2.3	1.6	1.3
p	ns	0.361	**0.007**	**0.020**	**0.006**	**0.070**	0.416	**0.024**
Sinan et al. 2012 [9]	4th hour	8th hour	12th hour	24th hour	48th hour			
SILC	5	2	2	1	0			
LC	5	3	2	1	0			
p	ns	ns	ns	ns	ns			
Zheng et al. 2012 [15]								Day 30
SILC								2.8
4PLC								3.7
p								**0.003**
Asakuma et al. 2011 [22]			Day 1					
SILC			2.4					
LC			4.5					
p			**0.002**					
Bucher et al. 2011 [16]	6th hour		24th hour			10 days		
SILC	2		1			1		
LC	3		3			2		
p	**<0.001**		**<0.001**			**<0.001**		
Ma et al. 2011 [17]	At discharge	Postoperative visit						
SILC	2.7	1.8						
LC	1.8	1.8						
p	**0.06**	ns						
Lai et al. 2011 [18]	6th hour					Day 7		
SILC	4.5					1		
LC	4					0		
p	ns					**0.48**		

(continued)

Table 4.3 (continued)

Aprea et al. 2011 [19]	6th hour		12th hour	24th hour				
SILC	3.9		4.5	2.8				
LC	3.5		4.0	2.2				
p	ns		ns	ns				
Cao et al. 2011 [20]			Day 1		Day 3			
SILC			2.3		1.3			
LC			2.6		1.5			
p			ns		ns			
Lirici et al. 2011 [1]	Day of surgery		Day 1	Day 2				Day 30
SILC	3.5		2	0.5				0
LC	2.5		2	0				0
p	**0.041**		ns	ns				ns
Tsimoyiannis et al. 2010 [23]	2nd hour	4th hour	6th hour	12th hour	24th hour	48th hour	72nd hour	
SILC	0.75	0.75	1.0	1.65	0.50	0.20	0.05	
LC	0.55	0.95	1.60	1.80	1.55	1.35	0.85	
p	ns	ns	ns	**0.001**	**<0.0001**	**<0.0001**	**<0.0001**	
Lee et al. 2010 [21]			Day 1					
SILC			2.1					
LC			2.2					
p			ns					

Table 4.4 Satisfaction with cosmetic results and quality of life

Marks et al. 2013 [13]/cosmesis	Preoperative	Day 1	Day 3	Day 5	1 week	2 weeks	Day 30	3 months	1 year
SILC					20.5	21.5	22.1	22.5	22.6
4PLC					18.6	18.5	19.2	20.0	20.2
p					**0.0004**	**<0.0001**	**<0.0001**	**<0.0001**	**0.003**
QoL									
SILC	49.1	31.0	36.8	42.0	44.4	47.5	51.1		
4PLC	50.1	31.8	40.1	44.1	47.5	49.7	54.1		
p	ns	ns	**0.01**	ns	**0.03**	0.32	**0.03**		
Zheng et al. 2012 [15]/satisfaction							Day 30		
SILC							8.9		
4PLC							8.1		
p							**0.012**		
Bucher et al. 2011 [16]/cosmesis[a]		Day of discharge			Day 10		Day 30		
SILC		6			5		5		
LC		8			7		6		
p		**<0.001**			**<0.001**		**0.003**		
QoL									
SILC							40		
LC							35		
p							**0.028**		
Ma et al. 2011 [17]/cosmesis					Postoperative visit				
SILC					9.3				
LC					8.9				
p					ns				
QoL									
SILC									
LC									
p					No difference				

(continued)

Table 4.4 (continued)

Lai et al. 2011 [18]/cosmesis				3 months
SILC				7
LC				6
P				**0.023**
Aprea et al. 2011 [19]/cosmesis[b]		Unknown postoperative		
SILC		4.9		
LC		3.5		
p		**<0.05**		
Lirici et al. 2011 [1]/cosmesis	Day of discharge		Day 30	
SILC	83.5 %		95.5 %	
LC	75 %		86 %	
p	ns		**0.025**	
QoL role emotional[c]				
SILC			80.05	
LC			68.33	
p			**0.001**	
Lee et al. (2010)[21]			Day 30	Months 6
SILC			8.7	9.1
LC			7.7	8.4
p			**0.001**	**0.042**

[a]Lower score better than the higher
[b]Wound satisfaction score
[c]Difference was significant only for role emotional

advantage for patients were "self-evident," this skepticism brought to a slow acceptance and worldwide diffusion of laparoscopy.

Each technique has its own specific complication profile [27] that must be accepted as a part of innovation; when analyzing results of the single access approach to cholecystectomy, we should bear in mind that laparoscopic cholecystectomy is nowadays a very well-standardized technique, safe, and often performed as an outpatient or 1-day surgery procedure and that very little room for improvements is left. Furthermore, most general surgeons can perform CLC proficiently, whereas performing SALC requires specific additional training [26].

Promoters of SALC stress that the expected major benefits of this procedure are reduced pain and better cosmetics. Nevertheless, less postoperative pain is not yet confirmed by randomized trials and meta-analyses.

In spite of our natural tendency to believe that one modest incision would hurt less than four standard laparoscopic incisions, the converse may be probably true [30]. Blinmann et al. as reported by Garg et al. [27] showed that total tension – and hence pain – across a wound rises nonlinearly by increasing wound length. Tension rises in proportion to the square of wound length, instead. Therefore, total tension across multiple incisions may be less than total tension across a single incision the length of which is equal to or greater than the sum of 3–4 standard laparoscopic incisions. In Blinmann study, the calculated total tension across two 10-mm and two 5-mm port CLC wounds and that across a single SALC wound were found to be similar [27].

Satisfaction with the cosmetic results has been demonstrated to be superior in SALC patients than in CLC patients in all randomized studies and meta-analysis. In 2012, Hey et al. published data on surgery of choice in possible candidates to SALC: postoperative images taken after SALC or CLC were shown to all patients awaiting elective cholecystectomy and patients were asked which procedure would they have preferred being based on these pictures. The same question was asked after completion of a questionnaire constructed using published objective data comparing reported outcomes of SALC and CLC. Only 16 % of subjects opted for CLC before questionnaire completion; this percentage increased up to 88 % after knowing outcome data of both procedures ($p < 0.001$). These data show that the risk for complications has a higher influence than cosmetic results in determining the choice of procedure [31]. The bias of this study is that data of a well-established procedure were compared to early data of a procedure that may be still in its learning curve phase. Furthermore, in a "willingness to pay" survey conducted within the Marks et al. study, only a little more than 50 % of patients stated that they would have accepted to pay more for undergoing SALC instead of CLC [13].

Although not significant, a trend toward higher complication rates in SALC patients has been recognized and this aspect must be further investigated: the doubt that a larger number of patients enrolled in future studies as well as longer follow-ups may lead to significant differences does exist. Possible explanation of this raised risk of complications is the demonstrated significantly impaired exposure of the operating field in SALC compared to CLC [1] and the overall higher difficulty of SALC, as subjectively assessed by surgeons [12]. Even though, with the end of their learning curve, surgeons will become more and more confident with this new approach and this will affect positively postoperative results, there is a general agreement among authors that SALC is more difficult than CLC, opinion confirmed by the operating time that remains longer even after the learning curve is completed.

The role of SALC is still controversial. Laparoscopic cholecystectomy through this new approach has to be performed in selected patients thus enhancing its potential benefits. This point is of utmost relevance: almost all published studies with the highest evidence did not include patients definitely considered candidate to a technically demanding cholecystectomy. Surgeons should not forget that, as for the time being, published data suggest that SALC, if compared to CLC, requires longer operating time with same postoperative pain, same length of hospital stay, and higher in-hospital costs when disposable instruments are used. Overall satisfaction is the only clear advantage of SALC, and this is mainly related to cosmetic results. However, it is still not clear whether this may turn in better postoperative quality of life. As a matter of fact, nobody has yet shown that patients are dissatisfied with conventional laparoscopic cholecystectomy [3].

References

1. Lirici MM, Califano AD, Angelini P, Corcione F (2011) Laparo-endoscopic single site cholecystectomy versus standard laparoscopic cholecystectomy: results of a pilot randomized trial. Am J Surg 202:45–52
2. Allemann P, Schafer M, Demartines N (2010) Critical appraisal of single port access cholecystectomy. Br J Surg 97:1476–1480
3. Rodhes M (2010) Commentary on critical appraisal of single port access cholecystectomy. Br J Surg 97:1481
4. Connor S (2009) Single-port-access cholecystectomy: history should not be allowed to repeat. World J Surg 33:1020–1021
5. Nassar AHM, Ashkar KA, Mohamed AY, Hafiz AA (1995) Is laparoscopic cholecystectomy possible without video technology? Minim Invasive Ther Allied Technol 4:63–65
6. Lirici MM, Califano A (2010) Management of complicated gallstones: results of an alternative approach to difficult cholecystectomies. Minim Invasive Ther 19:304–315
7. Bagloo MB, Dakin GF, Mormino LP, Pomp A (2011) Single-access laparoscopic cholecystectomy with routine intraoperative cholangiogram. Surg Endosc 25(5):1683–1688
8. Schlager A, Khalaileh A, Shussman N, Elazary R, Keidar A, Pikarsky AJ, Ben-Shushan A, Shibolet O, Horgan S, Talamini M, Zamir G, Rivkind AI, Mintz Y (2010) Providing more through less: current methods of retraction in SIMIS and NOTES cholecystectomy. Surg Endosc 24(7):1542–1546
9. Sinan H, Demirbas S, Ozer MT, Sucullu I, Akyol M (2012) Single incision laparoscopic cholecystectomy versus laparoscopic cholecystectomy: a prospective randomized study. Surg Laparosc Endosc Percutan Tech 22(1):12–16
10. Hirano Y, Hattori M, Douden K, Shimizu S, Sato Y, Maeda K, Hashizume Y (2011) Single-incision plus one port laparoscopic anterior resection for rectal cancer as a reduced port surgery. Scand J Surg 101:283–286
11. Pietrabissa A, Sbrana F, Morelli L, Badessi F, Pugliese L, Vinci A, Klersy C, Spinoglio G (2012) Overcoming the challenges of single-incision cholecystectomy with robotic single-site technology. Arch Surg 147(8):709–714

12. Ostlie DJ, Jaung AD, Iqbal CW, Sharp SW, Snyder CL, Andrews WS, Sharp RJ, Holcomb GW III, St Peter SD (2013) Single incision versus standard 4-port laparoscopic cholecystectomy: a prospective randomize trial. J Pediatr Surg 48:209–214
13. Marks JM, Phillips MS, Tacchino R, Roberts K, Onders R, DeNoto G, Gecelter G, Rubach E, Rivas H, Islam A, Soper N, Paraskeva P, Rosemurgy A, Ross S, Shah S (2013) Single-incision laparoscopic cholecystectomy is associated with improved cosmesis scoring at the cost of significantly higher hernia rates: 1-year results of a prospective randomized, multicenter, single-blinded trial of traditional multiport laparoscopic cholecystectomy vs single-incision laparoscopic cholecystectomy. J Am Coll Surg 216(6):1037–1047
14. Leung D, Yetasook AK, Carbray J, Butt Z, Hoeger Y, Denham W, Barrera E, Ujiki MB (2012) Single-incision surgery has higher cost with equivalent pain and quality of life scores compared with multiple incision laparoscopic cholecystectomy: a prospective randomized blinded comparison. J Am Coll Surg 215(5):702–708
15. Zheng M, Qin M, Zhao H (2012) Laparoendoscopic single-site cholecystectomy: a randomized controlled study. Minim Invasive Ther Allied Technol 21:113–117
16. Bucher P, Pugin F, Buchs NC, Ostermann S, Morel P (2011) Randomized clinical trial of laparoendoscopic single-site versus conventional laparoscopic cholecystectomy. Br J Surg 98:1695–1702
17. Ma J, Cassera MA, Spaun GO, Hammil CW, Hansen PD, Aliabadi-Wahle S (2011) Randomized controlled trial comparing single-port laparoscopic cholecystectomy and four-port laparoscopic cholecystectomy. Ann Surg 254(1):22–27
18. Lai ECH, Yang GPC, Tang CN, Yih PCL, Chan OCY, Li MKW (2011) Prospective randomized comparative study of single incision laparoscopic cholecystectomy versus conventional four-port laparoscopic cholecystectomy. Am J Surg 202:254–258
19. Aprea G, Coppola Bottazzi E, Guida F, Masone S, Persico G (2011) Laparoendoscopic single site (LESS) versus classic video-laparoscopic cholecystectomy: a randomized prospective study. J Surg Res 166(2):e109–e112
20. Cao ZG, Cai W, Qin MF, Zhao HZ, Yue P, Li Y (2011) Randomized clinical trial of single-incision versus conventional laparoscopic cholecystectomy: short-term operative outcomes. Surg Laparosc Endosc Percutan Tech 21(5):311–313
21. Lee PC, Lo C, Lai PS, Chang JJ, Haung SJ, Lin MT, Lee PH (2010) Randomized clinical trial of single-incision laparoscopic cholecystectomy versus minilaparoscopic cholecystectomy. Br J Surg 97:1007–1012
22. Asakuma M, Hayashi M, Komeda K, Shimizu T, Hirokawa F, Miyamoto Y, Okuda J, Tanigawa N (2011) Impact of single-port cholecystectomy on postoperative pain. Br J Surg 98:991–995
23. Tsimoyiannis EC, Tsimogiannis KE, Pappas-Gogos G, Farantos C, Benetatos N, Mavridou P, Manataki A (2010) Different pain scores in single transumbilical incision laparoscopic cholecystectomy versus classic laparoscopic cholecystectomy: a randomized controlled trial. Surg Endosc 24:1842–1848
24. Zehetner J, Pelipad D, Darehzereshki A, Mason R, Lipham JC, Katkhouda N (2013) Single access laparoscopic cholecystectomy versus classic laparoscopic cholecystectomy: a systematic review and meta-analysis of randomized controlled trials. Surg Laparosc Endosc Percutan Tech 23(3):235–243
25. Pisanu A, Reccia I, Porceddu G, Uccheddu A (2012) Meta-analysis of prospective randomized studies comparing single-incision laparoscopic cholecystectomy (SILC) and conventional multiport laparoscopic cholecystectomy (CMLC). J Gastrointest Surg 16: 1790–1801
26. Hao L, Liu M, Zhu H, Li Z (2012) Single-incision versus conventional laparoscopic cholecystectomy in patients with uncomplicated gallbladder disease: a meta-analysis. Surg Laparosc Endosc Percutan Tech 22(6):487–497
27. Garg P, Thakur JD, Garg M, Menon GR (2012) Single-incision laparoscopic cholecystectomy vs. conventional laparoscopic cholecystectomy: a meta-analysis of randomized controlled trials. J Gastrointest Surg 16:1618–1628

28. Wang D, Wang Y, Ji ZL (2012) Laparoendoscopic single-site cholecystectomy versus conventional laparoscopic cholecystectomy: a systematic review of randomized controlled trials. ANZ J Surg 82:303–310
29. Weiss HG, Brunner W, Biebl MO, Schirnhofer J, Pimpl K, Mittermair C, Obrist C, Brunner E, Hell T (2014) Wound complications in 1145 consecutive transumbilical single-incision laparoscopic procedures. Ann Surg 259(1):89–95
30. Rattner DW (2013) Beauty is in the eye of the beholder. J Am Coll Surg 216(6):1077–1048
31. Hey J, Roberts KJ, Morris-Stiff GJ, Toogood GJ (2012) Patients views through the keyhole: new perspectives on single-incision vs. multiport laparoscopic cholecystectomy. HPB 14:242–246

5 Single-Access Laparoscopic Surgery for Obesity

Roberto M. Tacchino and Francesco Greco

> He that will not apply new remedies must expect new evils;
> for time is the greatest innovator. Francis Bacon ~1600

When we completed our first single-incision cholecystectomy in 2007, we thought that, given the large number of cholecystectomies performed by general surgeons, it would have become rapidly popular for its simplicity and attractiveness. Nothing could be more wrong.

Facts proved that single incision was more rapidly applied to advanced laparoscopic procedure rather than to simple techniques like cholecystectomy and appendectomy.

The reason was that more skilled and more innovative surgeons did the more advanced procedures. It was impossible to convert a very conservative surgeon, which struggled enough to complete a simple laparoscopic procedure, to use single incision.

5.1 Patient Positioning

The patient is placed in supine position with the right arm abducted and the left arm along the body. The laparoscopic tower is placed in proximity of the patient's left shoulder. Surgeon operates at the right side of the patient while the assistant holds the camera, standing beside him. The scrub nurse is on the patient's left side (Fig. 5.1).

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_5,

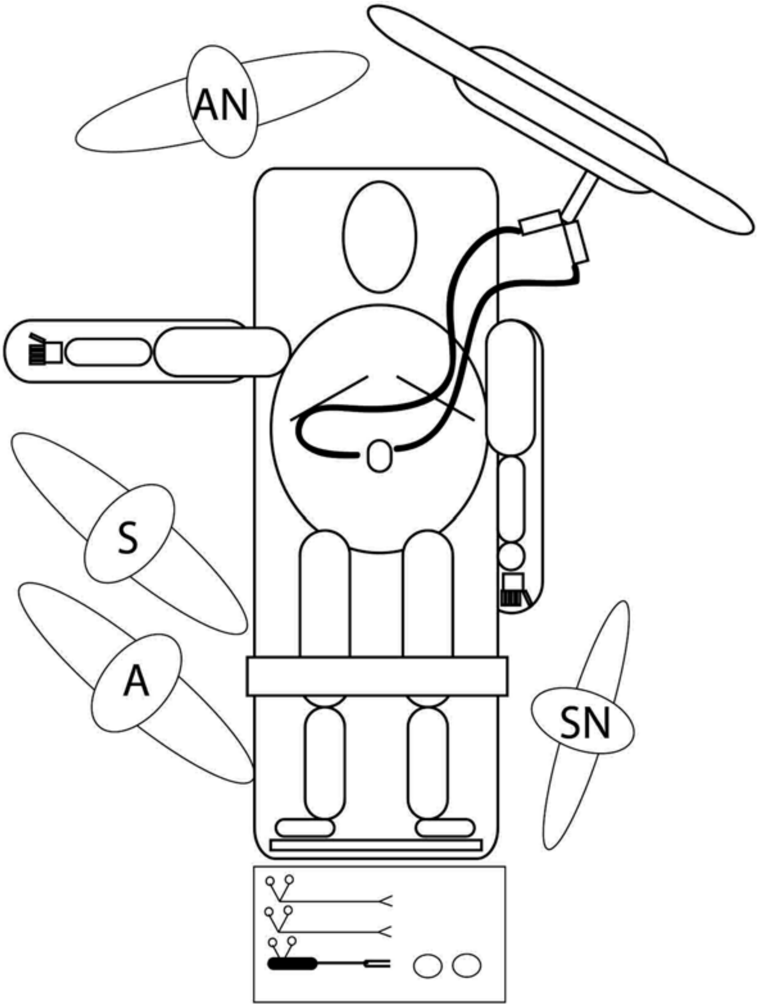

Fig. 5.1 OR setting: *S* surgeon, *A* assistant, *AN* anesthesiologist, *SN* scrub nurse. Note the Y connector on the insufflator delivering CO_2 to two separate lines

5.2 Access Port

The original technique used a 12-mm trocar that was put beside two Apple™ trocars (Apple Medical Corporation, Marlborough, MA, USA) through different fascial openings but through the same skin incision [1]. With three, very close to each other, fascial openings, there was a frequent loss of pneumoperitoneum, particularly when using large-bore instruments. This significantly reduced the quality of vision which, when too compromised, in fact made it impossible to continue with the intervention with the necessary safety.

Fig. 5.2 Common single-incision access ports

The advent of trocars with multiple channels, such as SILS-Port™ (Covidien, Mansfield, MA, USA), TriPort™ (Olympus Medical Systems, Hamburg, Germany), and Octoport™ (Dalim, Seoul, Korea), has significantly reduced this inconvenience (Fig. 5.2). The main differences are the presence or absence of rigid cannulas, the number and size of accesses, and the adaptability to wall thickness.

In order to totally hide the scar after surgery, the umbilicus is completely everted as a glove finger, and an Ellis clamp is affixed at its base so as to demarcate the cut that will be about 12 mm. At this level, the fascia and the skin are very close to each other so it is easy to gain access to the peritoneal cavity with an open technique. When repositioned, the incision and its scar will not be visible (Fig. 5.3).

5.3 Triangulation

The fundamental principle of single incision is instrument crossing in the navel where they enter the abdominal cavity. Thanks to the use of at least one articulated or curved instrument, paired with another instrument, either straight or articulated,

Fig. 5.3 Technique for umbilical incision. The umbilicus is everted as a glove finger. When repositioned, the incision will not be visible

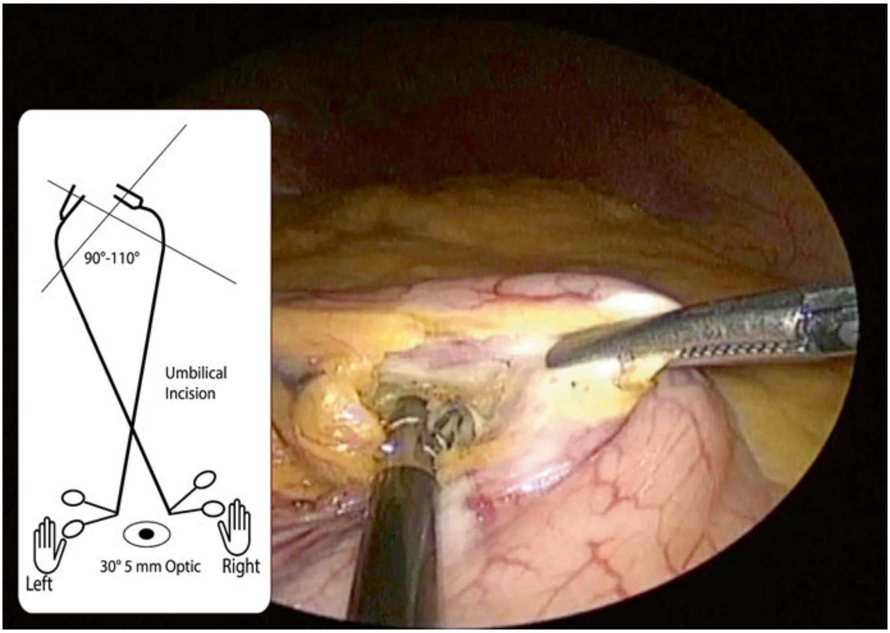

Fig. 5.4 The instruments cross each other at the umbilicus entrance point. With at least one curved or articulated instrument, it is possible to recreate an angle for traction. Note that the left hand is exerting traction, right side of the screen, while the right hand is dissecting the lesser curvature

it is possible to recreate a triangulation similar to that of conventional laparoscopy. As a consequence, the instrument held with the right hand is to be operated to the left on the screen and vice versa (Fig. 5.4).

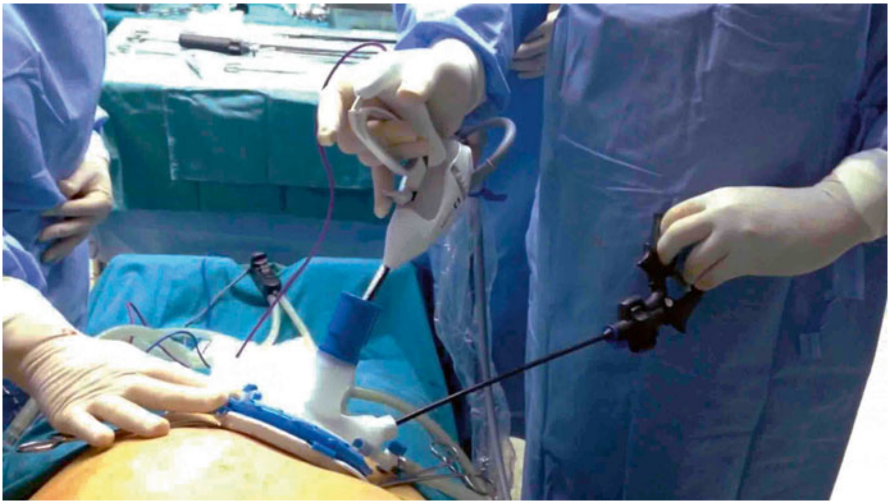

Fig. 5.5 Surgeon position. The instruments are used in an upside position to avoid clashing and interference with the abdominal wall. Wrist and arm position are comfortable and without stress

5.4 Exposure

The use of a long shaft, 30-degree and 5-mm scope, is mandatory not only to reduce to a minimum the friction in the port but also to facilitate its movement during the course of the intervention and in order to reduce clashing of the instruments, particularly outside the abdomen.

The use of a camera with articulated head (EndoEYE™ – Olympus Medical Systems, Hamburg, Germany) furthermore reduces the need for these movements and offers optimal visual angles, thus avoiding conflict with surgical instruments: it therefore should be regarded as a very useful instrument for this type of approach [2] (Fig. 5.5).

With regard to bariatric surgery, the need to expose the gastroesophageal junction, to perform anastomosis and suture, has posed specific problems: some steps need to be modified so that, for example, the use of a liver retractor would not be necessary [2, 3].

Retraction of the left lobe of the liver can be achieved with a transfix stitch, applied on the right crus and suspended percutaneously.

5.5 Patient Selection

When new surgical techniques are adopted, selecting suitable patients is recommended. Although evaluating parameters like distance from the xifhoid may be simple, in practice, it might not be enough.

Relative contraindications, also in relation to the surgeon's level of experience, such as a previous laparotomy or a previous laparoscopy, for which the navel was used as the access point, should be taken into account. In both cases, the difficulty of access or of positioning of the trocar in the peritoneal cavity should be verified. In fact, single-incision laparoscopy lacks the possibility of a provisional access for the camera at a point far from the navel or in any case of suspected adhesions, so that lysis can be performed to facilitate access.

In single-incision laparoscopy, the thickness of the abdominal wall is another feature to take into account as the port may not be sufficiently long to completely pass through it, and therefore, there might be a tendency to slide out, causing loss of the pneumoperitoneum and risk of damage when introducing the instrument.

A further consideration when selecting suitable patients is the position of the navel. The distance of the abdomen and hence the final position of the navel are difficult to determine in many cases, and it may be reasonably far from the initial position in the case of a large flaccid abdomen. In addition to that, the final distance at which the surgeon operates, such as the distance of the gastroesophageal junction from the navel, also depends on the patient's height and physical build.

The possibility, even at present, of having dedicated and extra-long instruments available must be part of these preoperative evaluations, although intraoperative evaluation remains crucial.

5.6 Restrictive Procedures

Restrictive procedures based on reduction of food intake include the gastric band and the sleeve resection (Fig. 5.6).

5.6.1 Sleeve Gastrectomy

Single-incision access and liver retraction are done as described above. The patient is placed in an anti-Trendelenburg position rotated to the right. The first step of the procedure is to dissect the angle of His to expose the left diaphragmatic pillar. Then we enter the lesser sac: LigaSure™ (Covidien, Mansfield, MA USA) 5 mm blunt tip 44 cm is used to open the gastroepiploic ligament enough to expose the posterior aspect of the angulus.

An orogastric calibration tube 40 Fr is inserted all the way to the pylorus. An Endo GIA™ (Covidien, Mansfield, MA USA) articulating 60 black reload is fired at a distance of about 6 cm from the pylorus toward the angulus. Suspension and correct traction of the stomach may require the use of transfix stitches passed through the stomach's greater curvature and percutaneously in the left hypocondrium to suspend from the outside. The vertical transection of the stomach is continued with applications of Endo GIA™ Articulating 60 purple or tan reload along the orogastric tube. No reinforcement of the transection line is needed. Complete dissection of the gastroesophageal junction is of utmost importance. Then the section of the gastroepiploic ärtery branches is continued upward to the angle of His paying attention to stay close to the gastric wall and preserving the

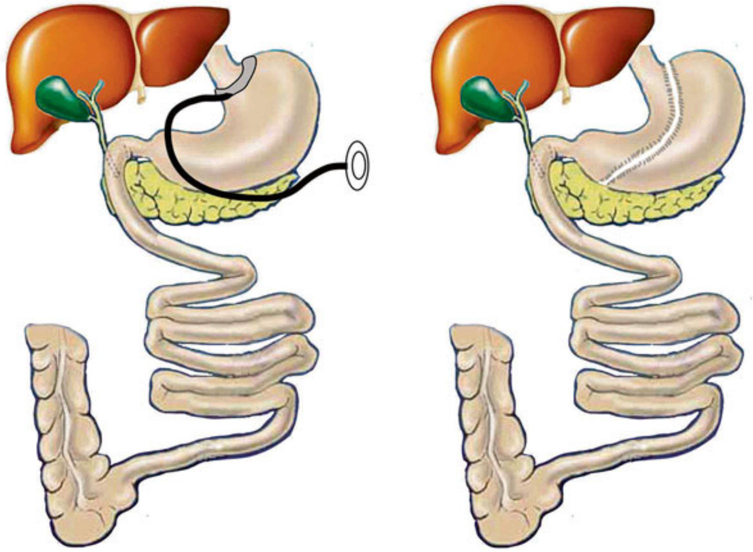

Fig. 5.6 Restrictive procedures. The band and the sleeve resection are based on creating an obstacle to passage of food or to reducing the capacity of the stomach

main artery branch. The patency and the tightness of the sleeve are tested with methylene blue. No drainage is left in place. The resected stomach is extracted, the pneumoperitoneum evacuated, and the port removed. The fascia is closed with an absorbable suture, and the navel is reinstated in its original position. We stress the pouch-first approach, which greatly facilitates the procedure particularly in single incision.

5.6.2 Gastric Band

Single-incision access and liver retraction is done as described above. The band-calibrated balloon-tipped orogastric tube is inserted into the stomach. Dissection of the angle of His is carried out as in the standard procedure using the SILS™ Clinch XL (Covidien, Mansfield, MA USA) in the left trocar and a regular hook in the right hand. A tunnel is created behind the stomach, as described for the pars flaccida technique. The dedicated band-articulating instrument is directed lateral to the equator of the calibration balloon and brought out at the angle of His. The band is closed around the stomach and the stoma calibrated using the inflated balloon (15 cm^3). Three retention gastro-gastric nonabsorbable sutures are applied to prevent band and/or stomach slippage. At the end of the procedure, a supraumbilical subcutaneous tunnel is made, and the access port is fixed above the fascia. Careful reconstruction of the umbilicus will allow it to be placed back in its original position, thus achieving a completely invisible scar.

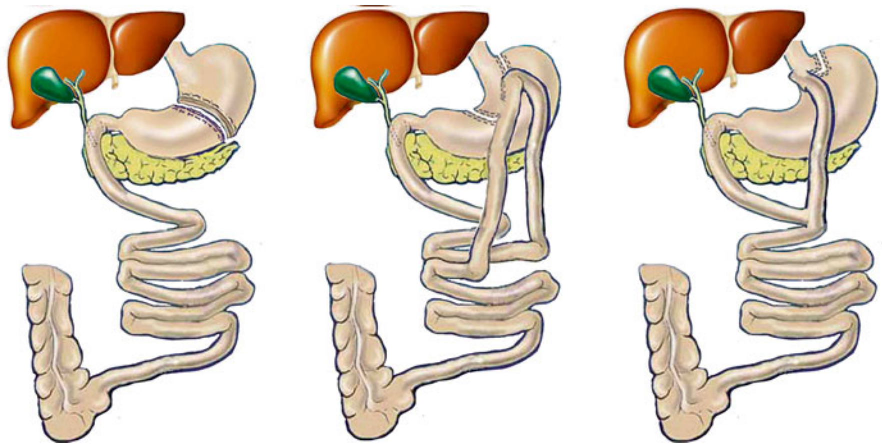

Fig. 5.7 Gastric bypass is defined by the exclusion of part of the stomach, duodenum, and portion of jejunum from food transit. Different pouch sizes determine the degree of food restriction; different limb lengths determine the degree of absorption limitation. *BPD* biliopancreatic diversion, *MGB* minigastric bypass, *RYGB* Roux-en-Y gastric bypass

5.7 Mixed Procedures

5.7.1 Gastric Bypass

This very popular procedure consists of excluding from food transit part of the stomach, the duodenum, and variable part of the jejunum (Fig. 5.7). The gastric pouch size varies from 15 to 500 ml. In the Roux-en-Y gastric bypass, the pouch is very small and the bowel limbs relatively short. The weight loss is based on food intake reduction. In the biliopancreatic diversion, the pouch is very big with little or no food restriction, but most of the bowel is excluded from food transit. The weight loss is obtained by limiting food absorption. The minigastric bypass has an intermediate pouch and limb lengths. The food intake is partially limited as well as food absorption.

5.7.1.1 Roux-en-Y

The first step of single-incision laparoscopic gastric bypass is the creation of a gastric pouch of about 6 cm in length, measured from the angle of His. A perigastric dissection is carried out with the use of LigaSure™ 5 mm blunt tip 44 cm coupled to a SILS™ Clinch XL that keeps traction on the stomach. The main trunk of the left gastric artery and the branches of the vagus nerve (the Latarjet) are preserved. Once the opening is made, an Endo GIA™ articulating 45 purple reload is fired, and the first transverse section of the stomach is done. A 40-Fr orogastric probe is brought forward filling the pouch and is used for calibration; the stapler is applied as close as possible to the probe to ensure a small volume of the pouch. The stomach is transected vertically. Two to three applications of Endo GIA™ articulating 60 purple or tan reload are necessary to reach the angle of His. The pouch is made narrow and long, similar to the old vertical banded gastroplasty. This method allows you to stay away from the esophagus and helps to decrease the tension on the gastroenteric anastomosis by decreasing the distance between the pouch itself and the bowel. A long and narrow pouch will initially create greater restriction. In an almost horizontal position, you perform the measurement of the bowel: the omentum is shifted upward, and to the left of the screen, the mesocolon is put under tension by pulling on an epiploic appendix in proximity of the left colic flexure, where it is thin enough and relaxed enough to allow easy exposure of the ligament of Treitz. The standard limb length is 75 cm for the biliary tract and 150 cm for the alimentary tract. The technique we use is called "double loop technique" in which a loop of the bowel is measured and immediately brought up antecolic to complete the gastroenteric anastomosis. This has three advantages: by minor adjustment of limb lengths, you can choose a loop of the bowel that has no tension, there is no confusion between the biliary and alimentary tract, and it is not necessary to interrupt the mesentery reducing the risk of bleeding and internal hernias. Gastroenteric anastomosis is made using an articulated Endo GIA™ articulating 45 blue reload. The service opening is hand-sewn with the Endo Stitch™ (Covidien, Mansfield, MA USA): it consists of an initial Connell introflecting layer and a second serosal muscular layer in Polysorbate® 2/0. At about 10 cm from the gastroenteric anastomosis along the biliary limb, an enterotomy is made for the next entero-enteric anastomosis. The second loop (alimentary limb) is measured up to 150 cm starting from the gastroenteric anastomosis just completed. With this technique the surgical field of view is very restricted, and the movements are minimized, thus facilitating the implementation of the intervention and reducing the risk of twisting the mesentery. We use an Endo GIA™ articulating 60 tan reload for the entero-entero anastomosis; the final closure of the gap is hand-sewn in double-layer Polysorbate® 2/0. The last step of the intervention is the interruption of the continuity between the two anastomoses to create the Roux-en-Y. Finally, the patency and the tightness of the gastroenteric anastomosis are tested with methylene blue. No drainage is left in place. The operation terminates with the evacuation of the pneumoperitoneum and the removal of the port. The fascia is closed with an absorbable suture, and the navel is reinstated in its original position.

5.7.1.2 Minigastric Bypass

The mini gastric bypass differs from standard Roux-en-Y gastric bypass in two aspects: the size of the gastric pouch and the way the gastroenteric anastomosis is performed. The first transection of the stomach is made much lower than in Roux-en-Y resulting in a longer pouch of about 12 cm in length. This pouch is very similar to a sleeve, very narrow and long. You need 3–4 hits of Endo GIA™ articulating 60 purple or tan reload to completely divide the pouch from the stomach. The biliary limb is measured up to 200 cm from the Treitz's ligament. After the enterotomy is done, an articulated Endo GIA™ articulating 60 blue reload is introduced into the bowel. With a movement of lateral translation, changing the angle of the stapler and turning it on the axis for 180°, we get into the proximity of the gastrotomy. The pouch is pulled down and the gastro-ileal anastomosis is performed. The service opening is closed with a hand-sewn suture performed with Endo Stitch™. The anastomosis is checked with the methylene blue test, while two clamps close both the afferent and efferent loops. The last step of the procedure is the creation of an antireflux mechanism: the first 5–6 cm of the afferent loop is sutured to the pouch vertically and so provides a preferential way for food and liquid traveling toward the alimentary/efferent limb and thus reduces the risk of reflux of bile into the pouch and of food in the afferent loop.

5.8 Malabsorptive Procedures

5.8.1 Biliopancreatic Diversion

The intervention [4] starts with the dissection at the level of the lesser curvature of the stomach at about 10 cm from the gastroesophageal junction. An articulated SILS™ Clinch XL keeps the stomach under traction, and dissection is performed with LigaSure™ 5 mm blunt tip 44 cm: these instruments are crossed, allowing to create a triangulation and exert the necessary traction and countertraction. Once the opening is made, the stomach is transected transversally with two applications of articulated Endo GIA™ Articulating 60 purple reload. The gastric pouch volume is about 350 ml. The gastrotomy is opened on the anterior surface of the pouch near the lesser curvature. The surgeon moves on the left side of the patient and the patient is put in almost horizontal position; the omentum is shifted upward and to the right hypocondrium, and the ileocecal valve is identified; two enterotomies are made at 50 and 250 cm from the ileocecal valve. Measurement of the bowel is done coupling a straight small bowel clamp with the articulated SILS™ Clinch XL, and enterotomies are opened with coagulating scissor and marked with a stitch. All sutures are applied using Endo Stitch™. The gastroenteric anastomosis is completed immediately using an articulated Endo GIA™ articulating 60 blue reload, the patient is put back into an anti-Trendelenburg position, and the gastric remnant is retrieved with the grasper; the anvil is placed in the jejunum 250 cm from the ileocecal valve, then the stapler is closed and shifted up approaching the gastric remnant while the direction of the joint is changed presenting the cartridge of the stapler in proximity to the gastrotomy. The service opening is closed with a double-layer hand-sewn suture. At about 10 cm from GE along the afferent limb, another enterotomy is made for the next entero-enteric anastomosis with the point at 50 cm from the ileocecal valve. We use an articulated Endo GIA™ articulating 60 tan reload; the entero-entero anastomosis and the service opening are closed with a double-layer hand-sewn Polysorbate™ 2/0 suture. The last step of the intervention consists of the interruption of the continuity between the two anastomoses to create the Roux-en-Y with an articulated Endo GIA™ articulating 60 tan reload. The patency and the tightness of the gastroentero anastomosis are tested with methylene blue. No drainage is left in place. The operation ends with the evacuation of the pneumoperitoneum and the removal of the port. The fascia is closed with an absorbable suture and the navel is reinstated in its original position.

5.9 Tips and Tricks

5.9.1 Patient Positioning

Supine positioning with the right arm extended and the left arm along the body enables completing the vast majority of all operations (Fig. 5.1). These procedures require the surgeon to operate on the patient's side and his assistant on the same side, while the scrub nurse with the instrument table is normally at the patient's left. The tower is positioned close to the left shoulder. A containment belt surrounds the patient's legs above the knees, and two foot supports guarantee stability in the anti-Trendelenburg position.

Remember to check how the table bends over itself. Inclination is the surgeon's third hand. For operations in the top upper lower part of the abdomen, you should consider that the gastroesophageal junction is very far from outside abdominal limits such as the xifhoid process because of the spherical conformation of the abdominal cavity. In general, you should rotate and incline the bed trying to approximate to you the site you have to operate on (e.g., the reverse Trendelenburg position "lowers" and draws the organs closer to the upper abdominal quadrant, and a subsequent rotation toward the right of the patient will help to access the splenic lodge; the Trendelenburg position, with simultaneous rotation toward the left of the patient, will expose the ileocecal valve and the appendix). Learning how and when to rotate and to incline the patient's position has different effects; one purpose is to turn away the structures that interfere with the exposure of the structures onto which you should operate.

5.9.2 Anastomosis

Completing a mechanic anastomosis in single-incision laparoscopy requires different steps: inserting the two claws of the stapler in both service holes is often not possible in one maneuver; in fact, when the distance between the two points is large, the best strategy would be to insert one claw of the stapler in the service hole of the most mobile bowel segment (e.g., the small intestine in the case of a gastroenteric anastomosis) and subsequently draw this bowel segment closer by using the stapler thus inserted in order to move it toward the second service hole.

The correct movement would be transfer and rotation, rather than pushing, in order to reduce the risk of trauma lesions on the bowel wall. Usually, the spatial disposition can be modified in our favor during this maneuver so as to reduce the traction on the intestinal clamps: to do this, it is useful to change the position of the table in order to "draw" the second service hole "closer."

This surgeon's maneuver must be carried out in coordination with the movement of the table and therefore with the collaboration and attention of the entire team in the operating theatre.

In general, it is better to introduce the anvil first and then the cartridge, using the wedge shape of the latter, to facilitate its introduction in the bowel: the two enterotomies are then carefully aligned in order to leave the service hole as small as possible.

5.9.3 How to Improve Vision by Reducing Smoke

Once the pneumoperitoneum has reached the programmed pressure value (15 mmHg), with the stopcocks closed, the flow supplied by the insufflator is zero so that there is no gas leak.

During the usual operative maneuver, the insertion/removal of the instruments in the trocar, the twisting of the trocar, and the strength applied on the wall during the course of the different maneuvers are responsible for small and discontinued gas leaks that are automatically replaced by the insufflator with discontinuous gas flow.

Recording of pressure values higher than those programmed (15 mmHg) inside the abdominal cavity is always attributable to additional pressure exerted from outside or, in most cases, to the patient's muscle contraction caused by inappropriate muscle relaxation.

During dissection, it is recommended to maintain ventilation in order to create a continuous gas outflow of approximately 5–6 l per minute so as to maintain the operative field free from smoke. Rotating and opening one of the trocar's stopcocks, we can obtain the desired outflow.

In order to maintain a constant and sufficient outflow and to be able to increase it by opening other "ventilation" as necessary, without compromising internal pressure with the subsequent collapse of the pneumoperitoneum, it is necessary to use all the power of the insufflator, which is usually 30–40 l per minute: in order to do this, the flow resistance must be reduced.

A simple Y-shaped gas outlet permits the connection of two, instead of one, silicon tube for the transport of gas inside the abdominal cavity.

The two tubes are connected to two different entries of the port, reducing the resistance to gas flow (Fig. 5.1).

Thanks to this simple device, you can leave a trocar stopcock partially opened and operate with a constant recycle of gas (flow should be 4–6 l/min), which minimizes the negative effects on vision of the smoke produced during dissection. If necessary, it is possible to completely open this stopcock thus increasing the outflow without the walls collapsing.

5.9.4 Learning to Take Advantage of the Space in Single-Incision Laparoscopy

Traction of an anatomical structure should be performed upward with the left hand (for right-handed surgeons): if we take into account that, in laparoscopy, the structure lies down flat, as if it was floating on the surface of a stretch of water, attempting to move it toward the right, or toward the left or downward, will always face resistance or conflict with other stuctures and with the camera, while the only limit with upward movements will be the top of the abdomen, distended by gas, inside which there will be no risk of encountering other structures; therefore, there will always be enough space for distension, traction, and exposure, thus allowing for an efficient operation.

We are used to apply strong traction with large excursion outward movements in order to tighten the knots. In this case, the space inside the abdominal cavity will often be insufficient to “pull” threads of certain length; the only solution is to use the “exit” path of the trocar pulling the instrument that tightens the thread toward the outside, and therefore toward us, where there will be no obstacles.

5.9.5 Learning from Single Incision

Single-incision laparoscopy is now known in many centers worldwide. Many publications report different acronyms and describe various technical variations reflecting the creativity and originality of the surgeons who first introduced this method, but at present, few randomized controlled trials have been completed [5–7]. For this reason, it is not possible to state with certainty that there are real benefits of this “new” surgery. We can assume a reduction of complications associated with the introduction of the trocar, such as bleeding and incisional hernias, and, of course, an advantage from the cosmetic point of view that makes the method extremely attractive to the patient. The absence of a final visible scar not only accounts for an aesthetic result but also has some psychological benefits: we know that many patients perceive surgery as a failure to control their own habits and do not want their friends and relatives know that they had been operated on. Indeed, we perceived a high level of satisfaction in the obese patients, who underwent single-incision bariatric surgery.

Although for matters regarding cholecystectomy, there are now several published works [7] and a substantial amount of case studies, in the field of bariatric surgery, single-incision technology is gaining ground more slowly since it is extremely complex.

There is a need for a larger learning curve and specific training in bariatric surgery centers that are already carrying out these interventions; at present, however, it is the privilege of a few [8].

Thus, as, after the introduction of laparoscopy, an initial increase of specific surgical complications has been observed, it is easy to foresee a similar trend after the spread of single-incision technology, although the difference between the two techniques is probably smaller than that of “open” surgery and laparoscopy.

What has so far facilitated the spread of this technique on a large scale is the possibility of “conversion” from single incision to traditional laparoscopy, which is easily achievable in the event of difficulties and limited to the introduction of one or two additional trocars, a simple maneuver, without the consequences of laparotomy, not only from the surgical point of view but also from the psychological point of view of the patient and surgeon, the so-called reduced ports surgery. This is a great advantage for its diffusion compared to other innovative techniques such as NOTES (natural orifice transluminal endoscopic surgery), combined with the fact that a single-incision intervention can also be performed with the help of fewer specific instruments than classic laparoscopy.

Several lessons can be learned from the single-incision experience.

The first aspect is about the access. While practicing single incision, you realize that any procedure can be carried on with only three ports, one for the camera and two for the operating instruments. This has beneficial consequences. It is only one surgeon who is manipulating the tissues and organs thus minimizing the trauma and more important the risk of damage by improper maneuvers of the assistant. The assistant is concentrated on holding the camera. You learn that to give good vision to the operating surgeon, the most important thing for the cameraman is to stand still and stay out of the way of the operating field. A mechanical camera holder can be used asking to the assistant only minor adjustments.

As you are using only three accesses when you go back, for any reason, to standard laparoscopy, you will still use three ports. You will not look anymore for an access to introduce a liver retractor that has been proven unnecessary. Thus, also in multiple port laparoscopy, you will reduce the number of ports with a benefit for the patient.

The second aspect concerns the surgical technique. Every step is reduced to the essential movements. No effort and time are spent to do "tricks" that we used to think important. And then the surgery becomes simple, less traumatic, and fast.

All these we learned from single incision, an approach that required some collateral thinking and freedom from prejudice.

We hope that the future will give more and more attention to reduced port laparoscopic surgery, always with the intent of offering the patient better care.

References

1. Tacchino R, Greco F, Matera D (2010) Laparoscopic gastric banding without visible scar: a short series with intraumbilical SILS. Obes Surg 20(2):236–239
2. Tacchino R, Greco F, Matera D, Diflumeri G (2010) Single-incision laparoscopic gastric bypass for morbid obesity. Obes Surg 20(8):1154–1160
3. Tacchino R, Greco F, Matera D (2008) Single-incision laparoscopic cholecystectomy: surgery without a visible scar. Surg Endosc 23:896–899
4. Tacchino R, Greco F, Matera D (2010) Single-incision laparoscopic biliopancreatic diversion. Surg Obes Relat Dis 6(4):444–445
5. Steinemann DC, Raptis DA, Lurje G, Oberkofler CE, Wyss R, Zehnder A, Lesurtel M, Vonlanthen R, Clavien PA, Breitenstein S (2011) Cosmesis and body image after single-port laparoscopic or conventional laparoscopic cholecystectomy: a multicenter double blinded randomised controlled trial (SPOCC-trial). BMC Surg 11:24
6. Trastulli S, Cirocchi R, Desiderio J, Guarino S, Santoro A, Parisi A, Noya G, Boselli C (2013) Systematic review and meta-analysis of randomized clinical trials comparing single-incision versus conventional laparoscopic cholecystectomy. Br J Surg 100(2):191–208
7. Chamberlain RS, Sakpal SV (2009) A comprehensive review of single-incision laparoscopic surgery (SILS) and natural orifice transluminal endoscopic surgery (NOTES) techniques for cholecystectomy. J Gastrointest Surg 13(9):1733–1740
8. Agarwal BB, Chintamani AK, Goyal K, Mahajan KC (2012) Innovations in endosurgery-journey into the past of the future: to ride the SILS bandwagon or not? Indian J Surg Jun 74(3): 234–241

6 Single-Access Laparoscopic Approach for Gastric Surgery (Hiatal Hernia Repair and Gastric Resections)

Giovanni Dapri and Guy Bernard Cadière

6.1 Introduction

With the advent of natural orifice transluminal endoscopic surgery (NOTES), single-access laparoscopy (SAL) started to be popular, and various procedures have been reported to be feasible and safe [1].

Hiatal hernia repair with subsequent antireflux fundoplication [2–9] and gastric resections [10–18], usually performed by open surgery or conventional multitrocar laparoscopy (CML), have been showed to be feasible and safe through SAL. One of the most challenging aspects is the choice of the access site, because to be cosmetically acceptable, the umbilicus is obviously chosen, but the positioning of this latter in the abdomen besides an adequate size of gastric lesion to be resected are necessary to avoid difficulties to reach the hiatus or to get a final non-cosmetic result.

Furthermore, during SAL, two basic rules of general laparoscopy have to be respected: the video screen, the operative field, and the surgeon's head have to be on the same axis [19] and the optical system has to be the bisector of the working triangulation formed by the two ancillary effectors [20].

Another challenging aspect, during SAL gastric surgery, is the exposure of the hiatal region. In literature, different techniques and devices have been used like:

- the insertion of a classic 5-mm liver retractor [2, 10],
- the insertion of a Penrose drain at the triangular ligament [3],
- the insertion of the percutaneous Cerrahpasa retractor [5]
- the use of cyanoacrylate between the left liver lobe and the diaphragm [6] or tissue glue [11]
- the insertion of the percutaneous superficial hepatic sutures [7, 8] or transhepatic sutures [21]

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_6, © Springer International Publishing Switzerland 2014

- the fixation of a Penrose drain to the abdominal wall by sutures [9] or by an endo hernia stapler [22]
- the insertion of the boxing glove retractor [12]
- the placement of an expandable sponge under the left liver lobe [13]
- the anchoring of the bulldog to the falciform ligament [23]
- the use of the magnet forceps maneuvered by external magnets [24]

In this chapter, the techniques of Nissen (360°) and Toupet (270°) fundoplication, besides gastric resections, through transumbilical SAL are described using a developed technique with reusable trocars, conventional rigid scopes, curved reusable instruments according to DAPRI (Karl Storz-Endoskope, Tuttlingen, Germany), and, as liver retractor, 1.8-mm trocarless grasping forceps according to DAPRI (Karl Storz-Endoskope).

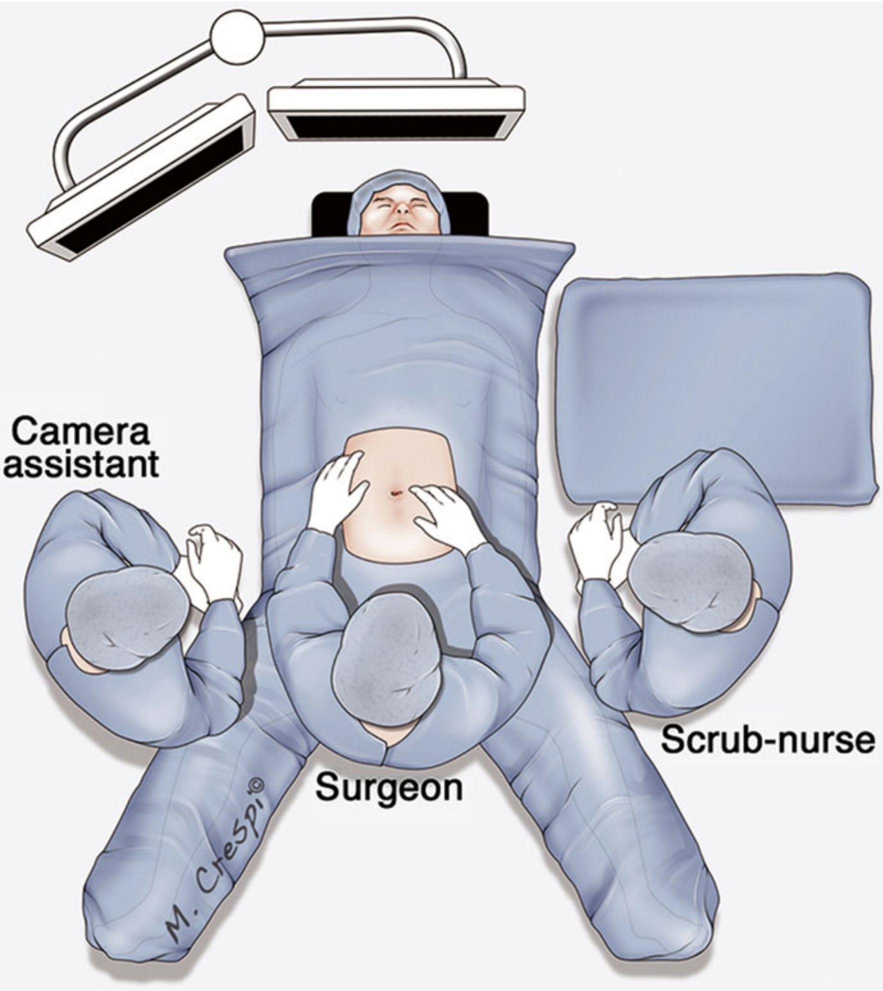

Fig. 6.1 Patient and team positioning

6.2 Laparoscopic Techniques

6.2.1 Patient and Team Positioning

The patient is placed in a supine position, with the arms alongside the body and the legs apart. The surgeon stands between the patient's legs, the camera assistant to the patient's right, and the scrub nurse to the patient's left. The video monitor is placed in front of the surgeon and camera assistant (Fig. 6.1).

6.2.2 Hiatal Hernia Repair

6.2.2.1 Beginning of the Procedure

The umbilicus is incised, and the fascia is opened until the peritoneal sheet is reached, which is opened as well. A purse-string suture using PDS 1 is placed in full-thickness method in the umbilical fascia and peritoneum at 1-, 3-, 5-, 6-, 7-, 9-, 11-, and 12-o'clock positions (Fig. 6.2). An 11-mm reusable metallic trocar is introduced into the peritoneal cavity inside the purse-string suture, and the pneumoperitoneum is created. A 10-mm, 30° rigid and standard length scope (Karl Storz-Endoskope) is advanced through the 11-mm trocar, and the DAPRI curved reusable instruments (Karl Storz-Endoskope) are inserted into the abdomen through the umbilical scar without trocars (Fig. 6.3). The bicurved grasping forceps III (Fig. 6.4a) is inserted through a separate fascia window, created by a wire of 5-mm trocar, at some of 5 mm, outside the purse-string suture at 10-o'clock position in respect of the patient's head. The other instruments like the monocurved coagulating hook (Fig. 6.4b), the monocurved scissors (Fig. 6.4c), the monocurved RoBi

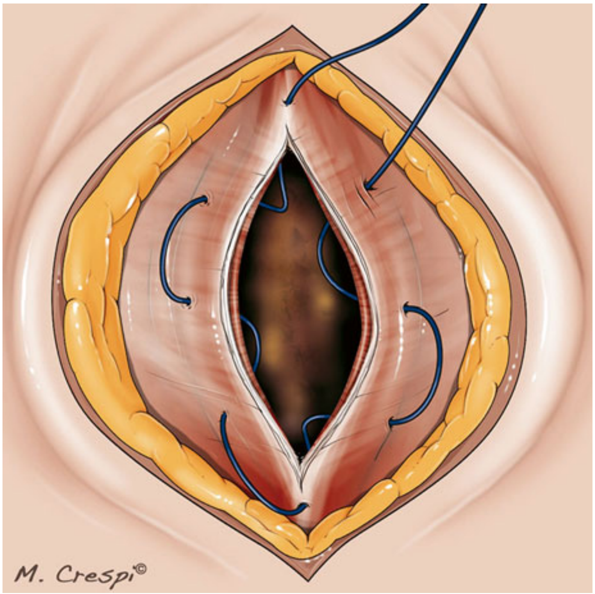

Fig. 6.2 Hiatal hernia repair: placement of the purse-string suture at the access-site (umbilicus)

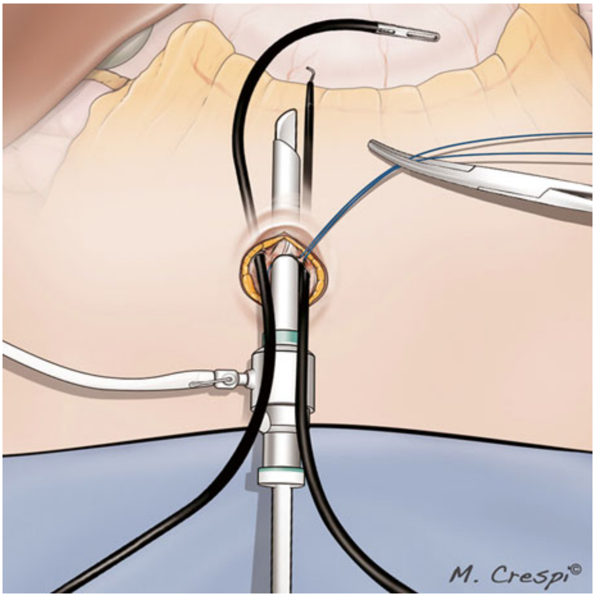

Fig. 6.3 Hiatal hernia repair: placement of the instruments through the access-site

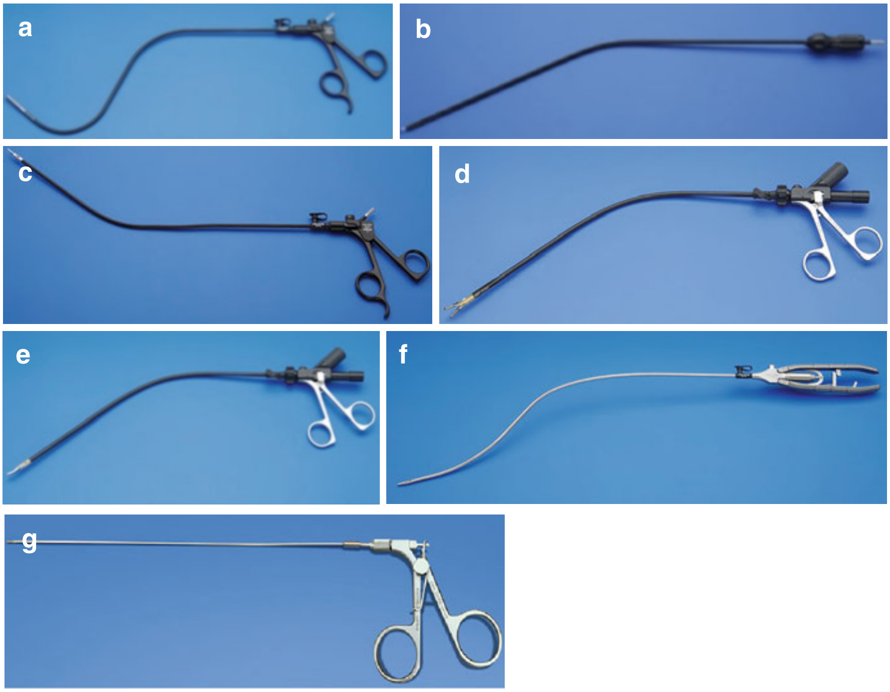

Fig. 6.4 DAPRI instruments: bicurved grasping forceps III (**a**), monocurved coagulating hook (**b**), monocurved sicssors (**c**), monocurved RoBi bipolar grasping forceps and scissors (**d**, **e**), bicurved needle holder II (**f**), straight 1.8-mm trocarless grasping forceps (**g**)

bipolar grasping forceps and scissors (Fig. 6.4d, e), the monocurved needle holder II (Fig. 6.4f), the monocurved suction and irrigation cannula, the straight 5-mm clip applier, and the straight 5-mm grasping forceps are introduced on the other side of

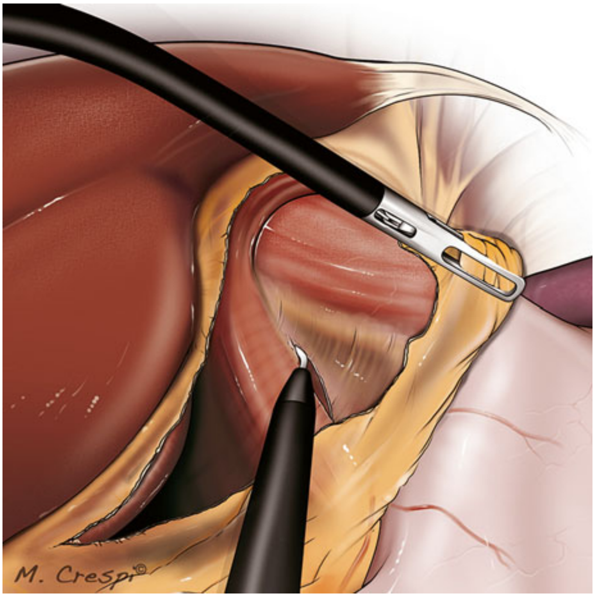

Fig. 6.5 Skeletonization of the right crus from bottom to top

the bicurved grasping forceps III at 3-o'clock position, parallel to the 11-mm trocar and inside the purse-string suture. The suture is adjusted to maintain a tight seal around the 5-mm tools and the 11-mm trocar and opened only for the change of the instruments and evacuation of the smoke created with the dissection. The operative table is positioned in a reversed Trendelenburg position.

The distal curve of the bicurved grasping forceps III is used to retract the left liver lobe and to contemporary expose the opening of the hepatogastric ligament on the lesser curvature. If an insufficient exposure of the hiatal region is shown, the DAPRI 1.8-mm trocarless grasping forceps (Karl Storz-Endoskope) (Fig. 6.4g) is inserted percutaneously through a skin puncture under the xyphoid access, created by a Veress needle.

The hepatogastric ligament is opened close to the liver segment 1, and the right phrenogastric ligament is incised as well, dividing its anterior and posterior sheets. The right crus is freed from the bottom to top (Fig. 6.5). Thanks to the peculiar shape of the instruments, the scope never appeared in conflict with the instruments' tips, and the conflict between the surgeon's hands and the scope is avoided (Fig. 6.6). The left phrenogastric ligament is incised, and the left crus is exposed. The lower esophagus is freed, encircled, and suspended by a piece of cotton tape using the bicurved grasping forceps III (Fig. 6.7a). Thanks to this maneuver, both crura under the esophagus are better exposed and more easily freed (Fig. 6.7b).

The operative table is maintained in a reversed Trendelenburg position with right-sided tilt, permitting an increased exposure of the splenic region. The gastrosplenic ligament is incised starting from the previous dissection of the left phrenogastric ligament, to control the first short gastric vessel (Fig. 6.7c). Then, the operative table is replaced without any tilt maintaining the Trendelenburg position, in order to move the upper part of the gastric fundus behind the lower esophagus.

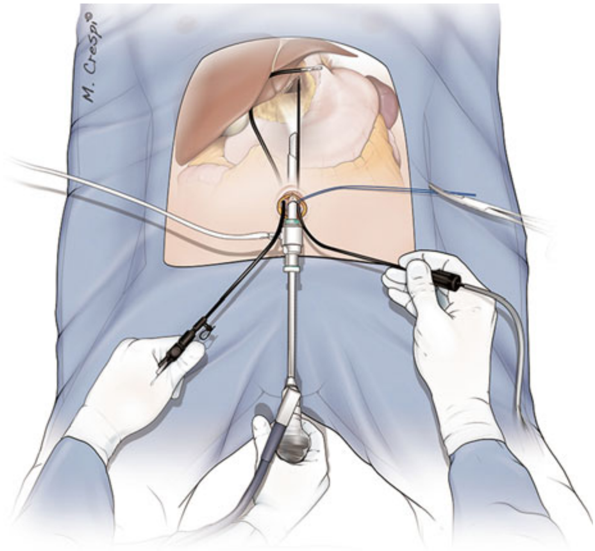

Fig. 6.6 The conflict between the surgeon's hands, and between the instruments' tips is avoided thanks to the peculiar curved shape of the instruments

The other short gastric vessels are just dissected "à la demand" giving a more slack to the wrap (Fig. 6.7d), using the monocurved coagulating hook or the monocurved bipolar grasping forceps and scissors.

Figure of 8 sutures using silk 2/0 are used to close the crura, using intracorporeal sutures and knotting technique (Fig. 6.8). This maneuver is realized without the orogastric bougie (34 French), which is pushed by the anesthesiologist only after the cruraplasty.

6.2.2.2 Nissen Fundoplication

The floppy 360° fundoplication is performed using intracorporeal sutures (silk 2/0) and knotting technique, under ergonomic position and without clashing of the instruments' tips (Fig. 6.9a). A gastro-gastric suture, a gastro-eso-gastric suture (Fig. 6.9b), and two gastroesophageal sutures inferiorly to the first previous and on both sides of the lower esophagus are performed (Fig. 6.9c).

6.2.2.3 Toupet Fundoplication

The 270° fundoplication is performed using silk 2/0 sutures. The right side of the wrap is fixed by four simple sutures to the right crura, starting with the first suture at the apex of the right crura. Then, the right side of the wrap is anchored to the lower esophagus by three other simple sutures. As well, the left side of the wrap is fixed to the left crura by two simple sutures, and then the left side of the wrap is anchored to the lower esophagus by three other simple sutures (Fig. 6.9d).

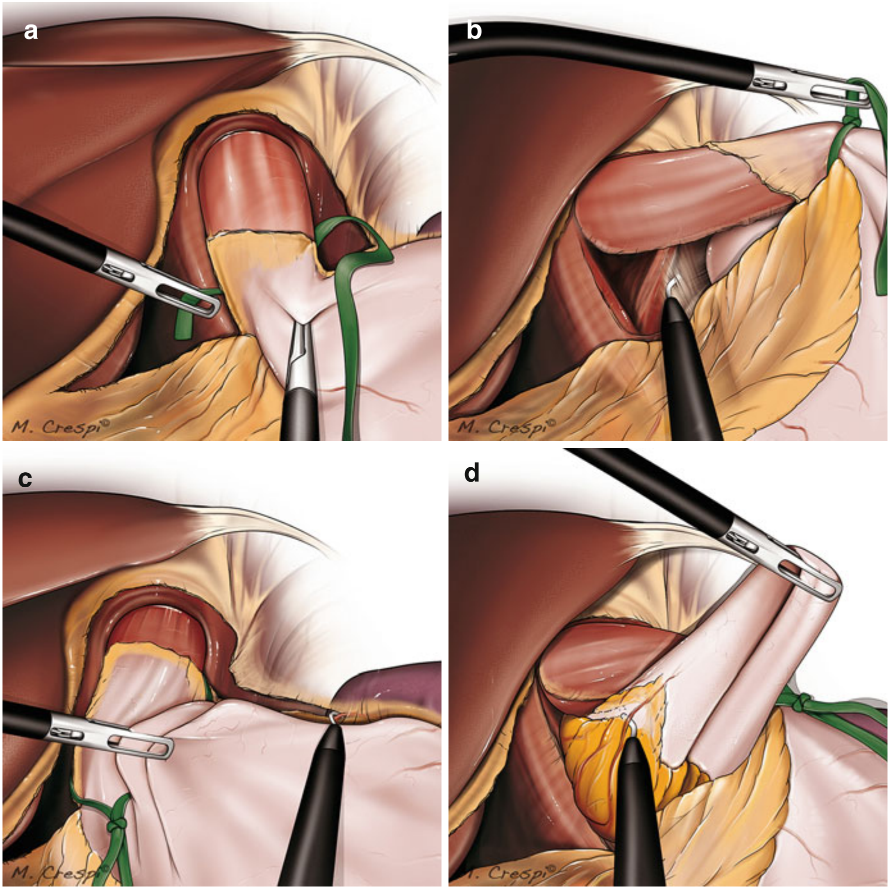

Fig. 6.7 The lower esophagus is encircled by a piece of cotton tape (**a**), permitting a better exposure of the both crura (**b**); control of the first short gastric vessel by a medial-to-lateral approach (**c**), and of the other short gastric vessels just “à la demand” by a medial-to-lateral approach (**d**)

6.2.2.4 End of Both Fundoplications

At the end of the procedure, the operative table is replaced like in the beginning of the procedure, without any Trendelenburg position and tilt. The orogastric bougie, the piece of cotton tape, the needles, and all the instruments are removed under view. The curved instruments are retrieved following their curves at 45° in respect of the abdominal wall.

The 11-mm trocar for the scope is removed, Vicryl 1 sutures are placed as figure of 8 to close the umbilical fascia, including the separate fascia opening for the bicurved grasper (Fig. 6.10). Intradermal sutures close the cutaneous scar.

6.2.2.5 Postoperative Care

One gram of paracetamol is given i.v. at the end of the surgical procedure. Postoperative analgesia is given following the WHO visual analog pain scale (VAS). In the recovery room, the following scheme is followed: for VAS between 1 and 3,

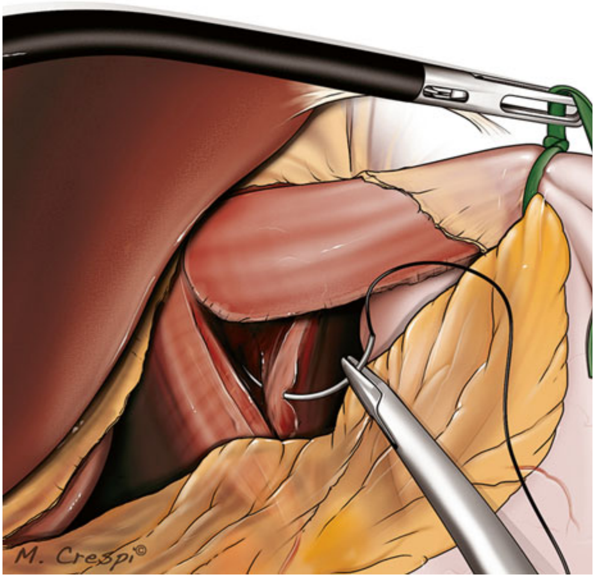

Fig. 6.8 Figure of 8 sutures are used to close the crura, using intracorporeal sutures and knotting technique

1-g paracetamol i.v. is pushed; for VAS between 4 and 8, 100-mg tramadol i.v. is used; and for VAS >8, 1-mg piritramide i.v. is incremented.

After the patient left the recovery room, pain is assessed every 6 h, with 1-g paracetamol administered i.v. if VAS is between 1 and 3, 100-mg tramadol administered i.v. if VAS is between 4 and 8, and 1-mg piritramide administered i.v. if VAS is >8.

A gastrograffin swallow check is scheduled on the first postoperative day, and if negative, the patient is allowed to drink water and, after 24 h, to tolerate a light diet. If there are no complications, the patient is discharged on the second postoperative day.

Upon discharge, 1-g paracetamol perorally or 50-mg tramadol perorally is prescribed only if needed.

Office visits are scheduled at 10 days, 1, 3, 6, and 12 months after the procedure. Barium swallow checks are performed at 6 and 12 months.

6.2.3 Gastric Resections

6.2.3.1 Beginning of the Procedure

The umbilicus is incised, and the fascia is opened until the peritoneal sheet is reached, which is opened as well. A purse-string suture using PDS 1 is placed in full-thickness method in the umbilical fascia and peritoneum at 1-, 3-, 5-, 6-, 7-,

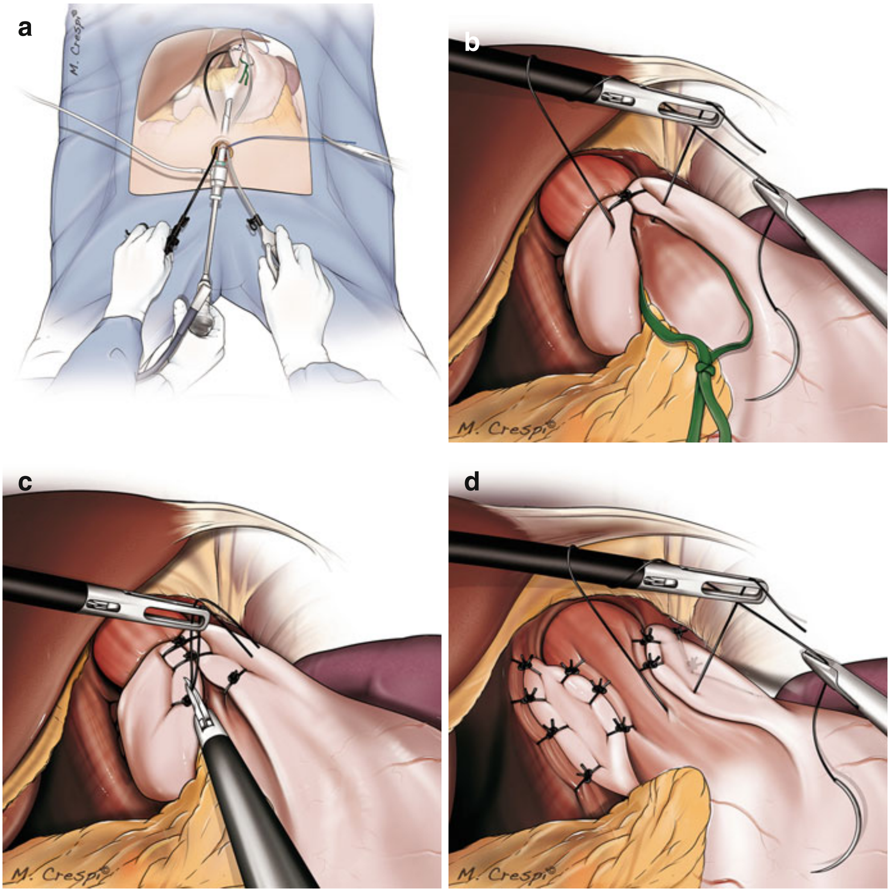

Fig. 6.9 The fundoplication is performed under ergonomic position and without clashing of the instruments' tips (**a**); Nissen fundoplication (**b**, **c**); Toupet fundoplication (**d**)

9-, 11-, and 12-o'clock positions (Fig. 6.2). An 11-mm reusable metallic trocar is introduced into the peritoneal cavity inside the purse-string suture, and the pneumoperitoneum is created. A 10-mm, 30° rigid and standard length scope (Karl Storz-Endoskope) is advanced through the 11-mm trocar, and the DAPRI curved reusable instruments (Karl Storz-Endoskope) are inserted into the abdomen through the umbilical scar. The bicurved grasping forceps III (Fig. 6.4a) is inserted through a separate fascia window, created by a wire of 5-mm trocar, at some of 5 mm, outside the purse-string suture at 10-o'clock position with respect of the patient's head. The other instruments like the monocurved coagulating hook (Fig. 6.4b), the monocurved scissors (Fig. 6.4c), the monocurved RoBi bipolar grasping forceps and scissors (Fig. 6.4d, e), the bicurved needle holder II (Fig. 6.4f), the monocurved suction and irrigation cannula, the straight 5-mm harmonic shears (Ethicon, Johnson & Johnson, Cincinnati, OH, USA), and the straight 5-mm grasping forceps

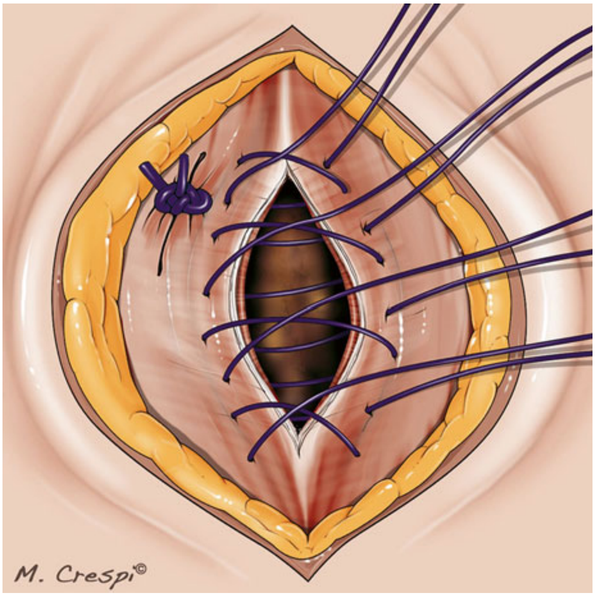

Fig. 6.10 Figure of 8 sutures are used to close the umbilical fascia, including the separate fascia opening for the bicurved grasper

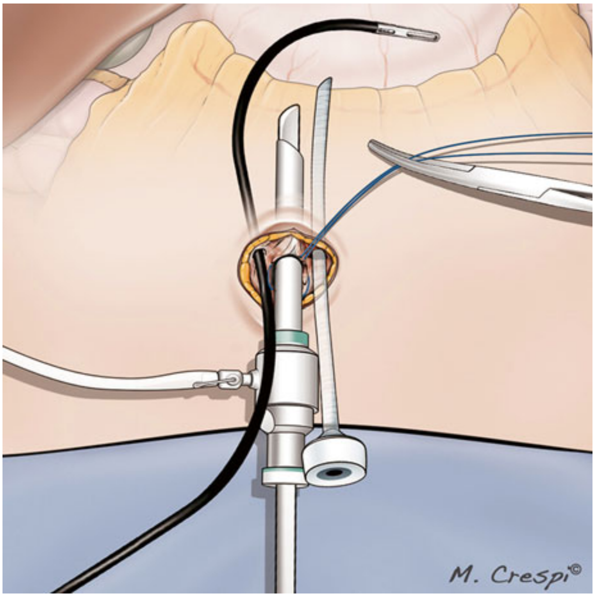

Fig. 6.11 Gastric resections: placement of the instruments and trocars through the access-site

are introduced through a 6-mm flexible trocar (Karl Storz-Endoskope) positioned at 5 mm outside the purse-string suture at 2-o'clock position with respect of the patient's head (Fig. 6.11). The suture is adjusted to maintain a tight seal around the 11-mm trocar. The operative table is positioned in a reversed Trendelenburg position.

Using the distal curve of the bicurved grasping forceps III, the left liver lobe is retracted but, if necessary, the DAPRI 1.8-mm trocarless grasping forceps (Karl Storz-Endoskope) (Fig. 6.4g) is inserted percutaneously through a skin puncture under the xyphoid access, created by a Veress needle.

Perioperative gastroscopy is helpful to localize the lesion into the stomach and to control the closure of the stomach at the end of the procedure.

A superficial temporary suture using Vicryl 2/0 is placed in the center of the lesion in order to retract the gastric wall, using the bicurved grasping forceps III and the curved needle holder II (Fig. 6.12a).

If the gastric resection includes the opening of the gastric wall, a device like a straight 5-mm harmonic shears (Ethicon Johnson & Johnson) is used; otherwise, the gastric wall remains closed and the resection is performed using firings of flexible linear stapler.

6.2.3.2 Resection with Stomach Opening

The suture placed in the center of the lesion is taken under tension by the bicurved grasping forceps III, and the gastric wall is resected around the lesion using the straight harmonic shears (Fig. 6.12b), staying distally for safe margins. An endoscopic grasper inserted by the gastroscope can be useful for the delimitation of the margins of the gastric resection (Fig. 6.12c).

Two converting running sutures (PDS 2/0), with preformed knots at their extremities, are used to close the gastric openings. The gastric closure is realized using the bicurved grasping forceps III and the bicurved needle holder II, under the gastroscopic control. Thanks to the peculiar shape of the instruments, the internal working triangulation of CML is established (Fig. 6.12d) and the surgeon continues to work in ergonomic position (Fig. 6.12e).

6.2.3.3 Resection Without Stomach Opening

The 11-mm trocar is replaced by a 13-mm reusable metallic trocar in order to accommodate a flexible linear stapler. The 10-mm scope is switched into a 5-mm, 30° rigid and long scope (Karl Storz-Endoskope), which is inserted through the 6-mm flexible trocar at 2-o'clock position (Fig. 6.13a). The suture, positioned at the beginning in the center of the lesion, is taken under tension by the bicurved grasping forceps III, allowing the placement of the linear stapler at the base of the gastric lesion (Fig. 6.13b). The linear stapler is fired staying at a safe margin from the lesion. During this step, the gastroscope is maintained intraluminally to control the resection. If necessary, the operative room table is adjusted with more right-sided or left-sided tilt, permitting an increased exposure of the operative field.

6.2.3.4 End of Both Gastric Resections

In order to perform the leak test, the gastric surface is immersed under physiologic solution using the monocurved suction and irrigation cannula, and the gastroscope evaluates the hermetic closure of the suture/stapler line (Fig. 6.14a).

A nonreusable custom-made plastic bag is introduced into the abdominal cavity through the metallic trocar. The resected lesion is placed inside the bag using the bicurved grasping forceps III and straight 5-mm grasping forceps (Fig. 6.14b) and removed transumbilically (Fig. 6.14c).

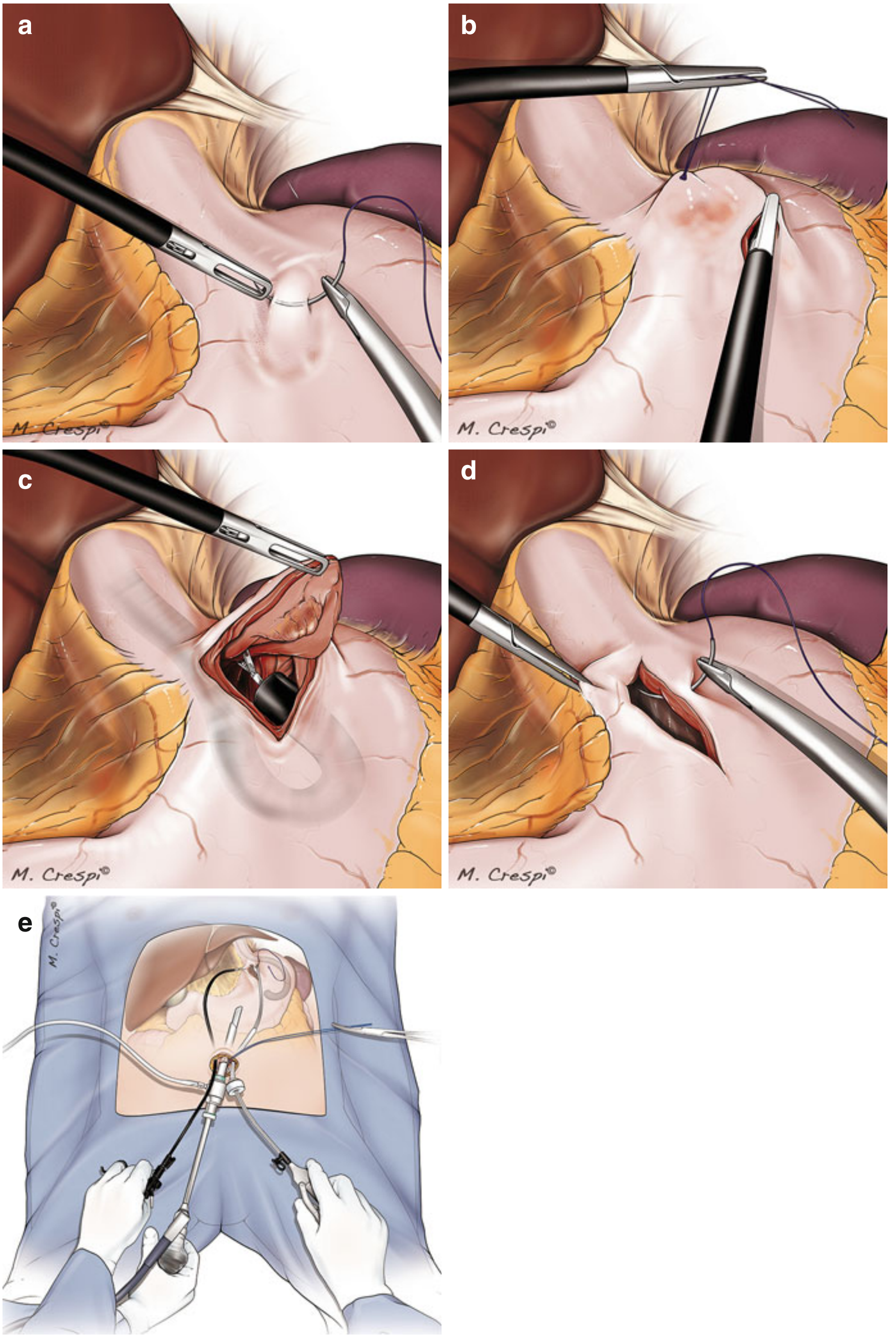

Fig. 6.12 Placement of a temporary superficial suture in the center of the gastric lesion to retract the gastric wall (**a**), which is resected maintaining safe margins (**b**) and under gastroscopic assistance (**c**); intracorporeal suturing (**d**) under surgeon's external ergonomy (**e**)

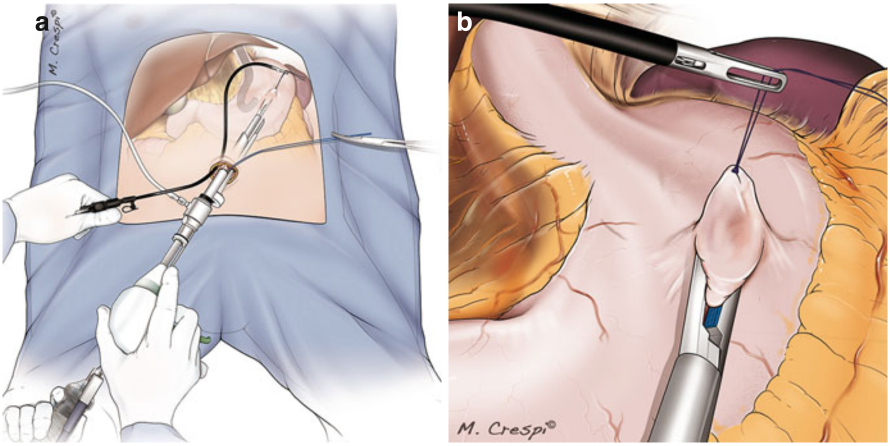

Fig. 6.13 Changement of the 11-mm trocar with a 13-mm reusable metallic trocar to accomodate the linear stapler and of the 10-mm scope with a 5-mm, 30º rigid and long scope (Karl Storz-Endoskope) (**a**); placement of the linear stapler at the base of the gastric lesion, taken-up by the lesion-suture-tension (**b**)

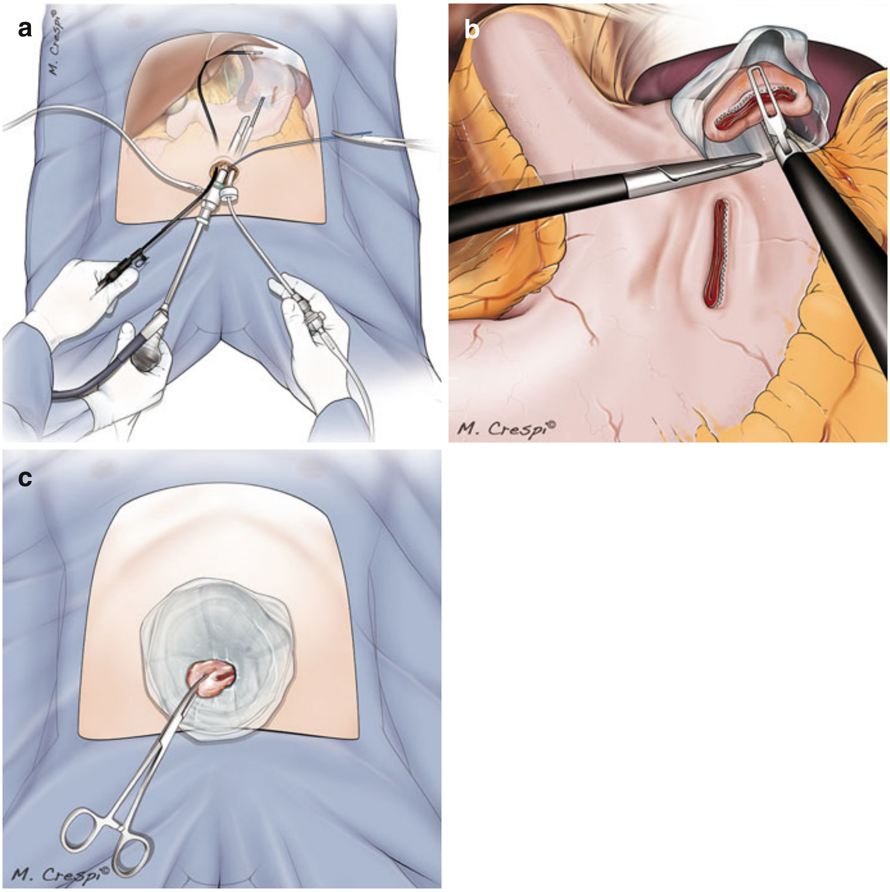

Fig. 6.14 Immersion of the gastric surface under physiologic solution for gastroscopic leak-test (**a**); placement of the resected lesion inside the bag (**b**) and its removal through the umbilical access (**c**)

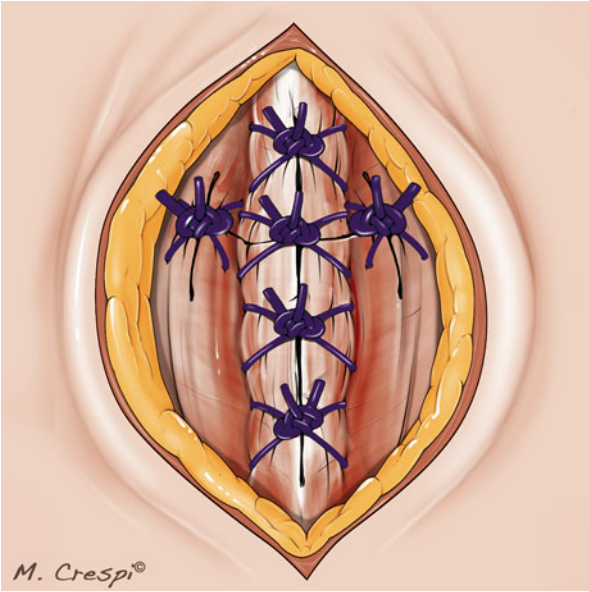

Fig. 6.15 Figure of 8 sutures are used to close the umbilical fascia, taking care to close the separate fascia opening for the bicurved grasper and for the flexible trocar

No drain is left in the abdominal cavity, but a nasogastric tube is placed under the laparoscopic view. The operative room table is replaced like in the beginning of the procedure, without any Trendelenburg position and tilt. The needles and all the instruments are removed under view. The bicurved grasping forceps III is retrieved following its curves at 45° in respect of the abdominal wall.

After the metallic trocar and the 6-mm flexible trocar are removed, Vicryl 1 sutures are placed as figure of 8 to close the umbilical fascia, taking care to close the separate fascial opening for the bicurved grasping forceps III and for the flexible trocar (Fig. 6.15). The cutaneous scar is closed by intradermal sutures.

6.2.3.5 Postoperative Care

One gram of paracetamol is given i.v. at the end of the surgical procedure. Postoperative analgesia is given following the WHO visual analog pain scale (VAS). In the recovery room, the following scheme is followed: for VAS between 1 and 3, 1-g paracetamol i.v. is pushed; for VAS between 4 and 8, 100-mg tramadol i.v. is used; and for VAS >8, 1-mg piritramide i.v. is incremented.

After the patient left the recovery room, pain is assessed every 6 h, with 1-g paracetamol administered i.v. if VAS is between 1 and 3 and 100-mg tramadol administered i.v. if VAS is between 4 and 8.

Antibiotic prophylaxis is prescripted for 48 h. The nasogastric tube is maintained in place until the fourth postoperative day. A gastrograffin swallow check is scheduled on the same day, and if negative, the patient is allowed to drink water the day after. A liquid diet is permitted since the sixth postoperative day, and if there are no complications, the patient is discharged on the same day.

Upon discharge, 1-g paracetamol perorally or 50-mg tramadol perorally is prescribed only if needed.

Office visits are scheduled at 10 days, 1, 3, 6, and 12 months after the procedure.

6.3 Indications and Contraindications

6.3.1 Hiatal Hernia Repair

Good indications are patients with 18< body mass index (BMI) <25 kg/m^2, height <1.75 m, and distance between the umbilicus and xyphoid access <20 cm. Acceptable patient's BMI is in the range between 25 and 30 kg/m^2, but with a BMI >30 kg/m^2, the transumbilical access appears too far from the hiatus. Moreover, sliding hiatal hernia and hernia <2 cm are good indications against the contraindicated bigger and paraesophageal hernias.

Contraindications to transumbilical SAL are male patients with a height >1.80–1.85 m, or patients with BMI >35 kg/m^2, or distance between the umbilicus and xyphoid access >25 cm, or presence of giant intrathoracic hernia, and obviously patients with surgical history in the hiatus.

6.3.2 Gastric Resections

Good indications are benign lesions with a diameter <5 cm or gastrointestinal stromal tumors <10 cm in diameter. The simple and feasible gastric location for SAL is the anterior surface or the greater curvature. Difficult gastric locations are the posterior wall, the smaller curvature, and the cardiac region.

Contraindications are huge and malignant tumors.

Finally, pure intraluminal resection of benign gastric lesions with successive mucosal wall closure is possible by transumbilical SAL, but the stomach has to reach the umbilicus in order to perform the gastrostomy and insert the port. Unfortunately, this technique, quite common in Asia [15], is difficult to apply to European and American patients due to their different physical status.

6.4 Tips and Tricks

6.4.1 Hiatal Hernia Repair

- The curved reusable instruments have to be inserted into the abdomen and removed from, following a 45° angle with respect of the abdominal wall.
- The distal curve of the bicurved grasping forceps III helps in the retraction of the left liver lobe. To improve the exposure of the hiatal region, other devices, needlescopic or millimetric instruments, have to be inserted under the xyphoid access and below the liver segment 2.

- The insertion of a piece of cotton tape to encircle the gastroesophageal junction helps in exposing the right and left crus and in performing the cruraplasty.
- Use of the bicurved needle holder II helps in minimizing the movement during the intracorporeal sutures. The instrument's tip has a 45° orientation in respect of the main shaft; hence, only a 15° rotation of the surgeon's wrist is needed to insert and remove the needle from the tissue.
- The operative table has to be used as an assistant's help, and it has to be placed in a reversed Trendelenburg position during the entire procedure with an increased patient's right-sided tilt during the step of the dissection of the short gastric vessels. After the first short gastric vessels have been sectioned, the rest of the fundus has to be freed "à la demand"; hence, a medial-to-lateral dissection is used, passing the fundus behind the gastroesophageal junction.
- Finally, the choice between the two fundoplications basically becomes from the results of the patient's preoperative work-up.

6.4.2 Gastric Resections

- The placement of a temporary suture on the gastric surface above the lesion helps in retracting the tissue for subsequent resection.
- The gastroscope has to be pushed down at the beginning of the procedure to explore the entire upper gastrointestinal tract. Then, staying intraluminally, it permits to control specimen resection and the subsequent gastric wall closure.
- Use of sutures with preformed knots at their extremities permits to gain time during the intracorporeal knotting technique.
- In front of a gastric lesion to be resected, the choice to remove the piece of the stomach with or without the gastric opening basically depends from the localization of the lesion and from the subsequent risk of stricture using the linear stapler.

References

1. Ahmed I, Paraskeva P (2011) A clinical review of single-incision laparoscopic surgery. Surgeon 9:341–351
2. Ross S, Roddenbery A, Luberice K et al (2013) Laparoendoscopic single site (LESS) vs. conventional laparoscopic fundoplication for GERD: is there a difference? Surg Endosc 27:538–547
3. Hamzaoglu I, Karahasanoglu T, Aytac E, Karatas A, Baca B (2010) Transumbilical totally laparoscopic single-port Nissen fundoplication: a new method of liver retraction: the Istanbul technique. Gastrointest Surg 14:1035–1039
4. Dapri G, Bruyns J, Himpens J, Cadière GB (2011) Single-access transumbilical laparoscopic Nissen fundoplication performed with new curved reusable instruments. Surg Innov 18:61–65
5. Eyuboglu E, Ipek T, Atasoy D (2012) Single-port laparoscopic floppy Nissen fundoplication: a novel technique with the aid of the Cerrahpasa retractor. J Laparoendosc Adv Surg Tech 22:173–175

6. Fan Y, Wu SD, Kong J, Su Y, Tian Y (2013) Transumbilical single-incision laparoscopic fundoplication: a new technique for liver retraction using cyanoacrylate. J Laparoendosc Adv Surg Tech 23:1–5
7. Nakajima J, Sasaki A, Obuchi T, Baba S, Umemura A, Wakabayashi G (2011) Single-incision laparoscopic Heller myotomy and Dor fundoplication for achalasia: report of a case. Surg Today 41:1543–1547
8. Yilmaz H, Alptekin H (2012) Single-port laparoscopic Nissen fundoplication: a new method for retraction of the left lobe of the liver. Surg Laparosc Endosc Percutan Tech 22:e265–e266
9. Yano F, Omura N, Tsuboi K et al (2012) Single-incision laparoscopic Heller myotomy and Dor fundoplication for achalasia: report of a case. Surg Today 42:299–302
10. Kunisaki C, Ono HA, Oshima T, Makino H, Akiyama H, Endo I (2012) Relevance of reduced-port laparoscopic distal gastrectomy for gastric cancer: a pilot study. Dig Surg 29:261–268
11. Kong J, Wu SD, Su Y (2013) Transluminal single-incision laparoscopy radical gastrectomy with D2 lymph node dissection for early gastric cancer-primary experience with less invasive surgery in China. J Laparoendosc Adv Surg Tech 23:141–145
12. Omori T, Oyama T, Akamatsu H, Tori M, Ueshima S, Nishida T (2011) Transumbilical single-incision laparoscopic distal gastrectomy for early gastric cancer. Surg Endosc 25:2400–2404
13. Takahashi T, Takeuchi H, Kawakubo H, Saikawa Y, Wada N, Kitagawa Y (2012) Single-incision laparoscopic surgery for partial gastrectomy in patients with a gastric submucosal tumor. Am Surg 78:447–450
14. Hirano Y, Watanabe T, Uchida T, Yoshida S, Kato H, Hosokawa O (2010) Laparoendoscopic single site partial resection of the stomach for gastrointestinal stromal tumor. Surg Laparosc Endosc Percutan Tech 20:262–264
15. Na JN, Lee SI, Noh SM (2011) The single incision laparoscopic intragastric wedge resection of gastric submucosal tumor. J Gastric Cancer 11:225–229
16. Park JY, Eom BW, Yoon H, Ryu KW, Kim YW, Lee JH (2012) Transumbilical single-incision laparoscopic wedge resection for gastric submucosal tumors: technical challenges encountered in initial experience. J Gastric Cancer 12:173–178
17. Park DJ, Lee JH, Ahn SH, Eng AKH, Kim HH (2012) Single-port laparoscopic distal gastrectomy with D1+B lymph node dissection for gastric cancers: report of 2 cases. Surg Laparosc Endosc Percutan Tech 22:e214–e216
18. Ozdemir BA, Thomas RL, Soon Y (2011) Single-port subtotal gastrectomy with DIα lymphadenectomy. Surg Innov 18:NP1–NP4
19. Hanna GB, Shimi SM, Cuschieri A (1998) Task performance in endoscopic surgery is influenced by location of the image display. Ann Surg 227:481–484
20. Hanna G, Drew T, Clinch P, Hunter B, Cuschieri A (1998) Computer-controlled endoscopic performance assessment system. Surg Endosc 12:997–1000
21. Huang CK (2011) Single-incision laparoscopic bariatric surgery. J Minim Access Surg 7:999–1003
22. Huang CK, Lo CH, Asim S, Houng JY, Huang SF (2011) A novel technique for liver retraction in laparoscopic bariatric surgery. Obes Surg 21:676–679
23. Galvani CA, Gallo AS, Gorodner MV (2012) Single-incision and dual-incision laparoscopic adjustable gastric band: evaluation of initial experience. Surg Obes Relat Dis 8:194–200
24. Morales Conde S, Dominguez G, Cañete Gomez J et al (2013) Magnetic-assisted single-port sleeve gastrectomy. Surg Innov 20:NP9–NP11

Single-Access Laparoscopic Splenectomy

7

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7.1 Introduction

Multiport laparoscopic splenectomy (LS) is considered the "gold standard" for the management of surgical diseases in normal or slightly enlarged spleens [1]. Its effectiveness and low complication rate, alongside patient comfort, decreased hospital stay, and enhanced recovery, make it the procedure of choice for most surgeons.

The concept of minimal invasive surgical techniques has progressed since the early 1990s, from standard multiport laparoscopy to natural orifice transluminal endoscopic surgery (NOTES) and, more recently, to single-port access (SPA). Experience with SPA has been reported sporadically since minimal invasive procedures (appendectomy, cholecystectomy) first appeared, but the number of papers on the subject has increased consistently since 2007, perhaps because surgeons view this technique as a bridge to the even lesser invasive NOTES [2]. Simultaneously, a concept of reduced port surgery (RPS) has emerged trying to overcome the difficulties of SPA. The reduction of the number and size of incisions as well as the use of natural orifices or scars permits to preserve the integrity of the abdominal wall, reduces the number and size of wounds, and improves the esthetic outcome [3].

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_7, © Springer International Publishing Switzerland 2014

7.2 Single-Port Splenectomy

7.2.1 Indications and Contraindications

The best indication for single-port splenectomy (SPS) is the case of slim patients with normal or slightly enlarged spleen. Previous surgery is not a definitive contraindication but, undoubtedly, increases the difficulty when adhesions should be taken down. There exist two anatomic features that increase or preclude SPS. They are the belly shape and the extremely tall patient. In the case of a prominent belly, the distance from the belly bottom to the splenic fossa increases and in some cases is not possible to reach the top of the posterior adhesions of the upper pole of the spleen. Also, in extremely tall patients, the distance from the umbilicus to the diaphragm is too long for the use of conventional endoscopic instruments. A solution for these situations may be the placement of the device just in the subcostal medioclavicular point. Then the working distance is reduced significantly. Other technical alternative is to introduce an additional 2- or 5-mm trocar at the left hypochondrium, and the use of this new instrument may permit to overcome dissection difficulties. This port site may be used as drainage exit in the case that it would be necessary.

Splenomegaly or liver cirrhosis is not an absolute contraindication but increases the difficulty of the dissection and removal maneuvers. Massive splenomegaly is a formal contraindication.

7.2.2 Surgical Technique

The patient is placed in the standard right decubitus position for LS, with the table flexed at the flank. A transumbilical approach can be chosen for thin patients and in cases of splenic cyst. In the case of tall, obese, or noncompliant abdomen, a left 2-cm subcostal incision is placed at a point between the subcostal margin and the umbilicus in the midclavicular line.

Single-incision splenectomy (SIS) can be performed through two approaches.

(a) SIS using multiple trocars. A 15-mm skin incision is made inside the umbilicus, and a 12-mm bladeless trocar (Excel Endopath, Ethicon Endo-Surgery, Cincinnati, OH, USA) is bluntly introduced into the abdomen under optic control with a flexible-tip 10-mm HD scope (Olympus, Center Valley, PA, USA). After exploring the abdominal cavity, a 5-mm trocar with a flexible corrugate shaft (Karl Storz, Culver City, CA, USA) is inserted into the left of the 12-mm trocar, and another 5-mm trocar with a small head is placed to the right.

(b) SAP splenectomy using a multiport device. After the insertion of the Veress needle, a 20-mm incision is made and a multiple-port device (TriPort, Quadriport, [Olympus], Uno [Ethicon], Applied [GelPort]) is inserted (Fig. 7.1).

The technique used for splenic dissection is similar to that used in standard LS. After an explorative laparoscopy, the possible existence of accessory spleens is ruled out. A 5-mm curved grasper used for transanal endoscopic microsurgery (TEM) (Richard Wolf, Vernon Hills, IL, USA) is placed through the left port.

Fig. 7.1 Intraoperative view of the multitrocar approach for a single-incision splenectomy

The slightly curved end of this instrument fits into the flexible trocar or through a port of the multichannel device, and it is sufficiently curved to work intra-abdominally without causing instruments to clash. A 5-mm harmonic scalpel (Harmonic Ace, Ethicon Endo-Surgery, Cincinnati, OH, USA) is then introduced through the right port. Using this approach, it is possible to mobilize the splenic colon flexure and to reach the lower pole of the spleen. The next step is to gain access to the retrogastric pouch and to severe the short vessels at the upper pole of the spleen. With this view, and thanks to the flexible tip of the scope, it is possible, if desired, to ligate or clip the splenic artery. The instruments are then moved to the posterior face of the spleen, and the table is tilted to the left to take advantage of gravity and obtain exposure of the retrosplenic area. The posterior splenorenal attachments are freed.

Sometimes, especially if the umbilical approach is used and there are some difficulties with the more posterior and upper part of the upper splenic pole, a 3-mm instrument can be introduced through the left flank. This mini-instrument can be used to retract or section (hook) retroperitoneal adhesion.

Once the spleen is completely mobile, the flexible scope is retrieved, and the intra-abdominal visual control is changed to a 5-mm scope. If the multichannel has several large bore ports (Qadriport, Olympus), the 10-mm scope can be maintained. A probe inserted through the left 5-mm trocar raises the splenic hilum, providing sufficient space for the placement of the stapler. A stapler with a 6-cm white cartridge (Echelon, Ethicon Endo-Surgery) is inserted through a 12-mm trocar/port and advanced to the splenic fossa. After adjusting the jaws, the stapler is applied several times to sever the splenic hilum.

Once the spleen is completely free, a 15-mm endobag (Endo Catch II; Covidien, Mansfield, MA, USA) is inserted. The spleen is grasped with a 5-mm instrument and hung in the splenic fossa. The bag is deployed below the organ and the spleen is introduced. The bag is pulled to the umbilical incision and the spleen is retrieved (intact or morcellated), and the operating field is revised and complete hemostasis is achieved.

In the case of fenestration of a splenic cyst, the first step is to puncture and evacuate the cyst content. Then, with the help of the harmonic scalpel, we excise the maximum segment of the wall cyst, reaching the spleen parenchyma. Once hemostasis is completed, cyst wall fragments are extracted in an endobag.

The umbilicus is closed and carefully reconstructed, obtaining an optimal esthetic result.

7.3 Reduced Port Splenectomy

Single-port access splenectomy (SPAS) emphasizes the concept of surgery through one small transabdominal incision rather than the standard multiple trocar sites, with theoretic benefits of less pain and better cosmetics. The incision can be hidden periumbilically and can be used as the specimen extraction site as well. Nevertheless, the SPAS approach for solid organs poses several technical challenges besides instrument clashing, difficult visualization, and limited range of movements. Firstly, solid organs cannot be grasped and retraction is more difficult. Secondly, during SPAS, exposure of the lesser sac and upper pole of the spleen is sometimes suboptimal. Thirdly, the approach trough the umbilicus in cases of high BMI or very tall patients may preclude one from reaching the spleen adequately. An alternative single access through a subcostal incision loses the esthetic advantages [4].

The reduced port access splenectomy (RPAS) approach represents a hybrid option between the standard LS and SPAS and makes it possible to perform the operation using less trocars of smaller sizes and taking advantage of the umbilical scar as the main entrance, thereby reducing the already minimal parietal trauma and improving the cosmetic outcome.

7.3.1 Surgical Technique

The patient is placed in lateral decubitus, and the access to the abdominal cavity is gained using a 12-mm optic bladeless trocar (Excel Endopath, Ethicon Endo-Surgery, Cincinnati, OH) introduced through the umbilicus. We routinely used a 10-mm flexible-tip HD scope (Endoeye, Olympus). A subcostal 5-mm trocar is placed under direct vision at the level of the anterior axillary line.

Fig. 7.2 Intraoperative placement of trocars in the case of reduced port splenectomy

Finally, a 3-mm port is inserted at the midepigastric region (Fig. 7.2). The sequential steps are essentially the same as with SPAS. Using a 5-mm harmonic scalpel (HARMONIC ACE, Ethicon Endo-Surgery) and 3-mm instruments (Storz, Tuttlingen), access was gained to the lesser sac by dividing the gastrosplenic ligament and short vessels until the upper pole of the spleen. Every attempt was made to ligate the splenic artery at the superior border of the pancreas to allow some shrinkage of the spleen. Next, splenic flexure of the colon was mobilized to get the lower pole of the spleen freed. The table was then tilted to the right to obtain a good exposure of the retrosplenic area, taking advantage of gravity. The posterior splenorenal ligament was then freed. Once the spleen was completely dissected free from all of its attachments, the optic was changed for a 5-mm, 30° scope introduced through the left hypochondrium trocar, and a stapler with a 60-mm white cartridge (Echelon, Ethicon Endo-Surgery) was deployed through the umbilical port, advanced to the splenic fossa, and fired to divide the splenic artery and vein at the level of the hilum. A 15-mm endobag (Endo Catch II, Covidien, Mansfield, MA) was used to retrieve the spleen after being morcellated trough the umbilical incision. A drain, exteriorized through the lateral 5-mm trocar, was used selectively.

7.4 Literature Review

7.4.1 Data Sources

A systematic search in PubMed (June 2013) was performed. The applied search strategy included the key words: (single incision OR single port) AND (laparoscopic OR laparoendoscopic OR robotic) AND splenectomy.

7.4.2 Case Reports of Single-Incision Laparoscopic Splenectomy

The main characteristics of the studies (demographics, medical history, clinical features of SILS performed, operative parameters, outcomes) are depicted in Table 7.1 [5–34]. A total of 81 patients were retrieved. The age ranged from 0.6 to 73 years. The majority of them were female (57 %). The median body mass index of the included patients was 23 kg/m^2 (range: 18–36). Partial splenectomy was performed in two cases (2.5 %). The patients were positioned either in semi-lateral (62 %) or lateral position (38 %). The most frequent surgical approach was through the umbilicus (91 %), while the supraumbilical (6 %) or left upper quadrant (2.5 %) was also used. The median weight of the spleen was 446 g (125–590 g). Regarding the utilized port system, a multitrocar system (5–12-mm trocars) were applied in (54 %) patients, SILS® port in 27 %, TriPort® in six (8 %), glove ports in five (6 %), and GelPort® in four patients (5 %).

The median operative time was 125 min (45–420), while the median blood loss was 50 ml (10–450 ml). In 5 % a conversion was needed either to open or to multiport laparoscopic surgery, while transfusion was needed in 11 cases (14 %). The hospital stay ranged between 1 and 9 days. Complications related to splenectomy occurred in 7 % of patients. No death of patients was reported. Simultaneously, we identified five case series that included 58 SILS patients (Table 7.2) [4, 35–38]. Only in one study, the final cosmesis of the surgical wounds was evaluated with the difference being statistically significant in the single-incision group compared to the classical laparoscopic one. A similar systematic review has recently been published [39].

7.5 Comment

During the last years and after the dissemination of the NOTES concept, a trend to reduce the access trauma by minimizing the abdominal wall injury in laparoscopic surgery has emerged, and after anecdotal approaches through NOTES-assisted techniques, the spleen has also been approached by SPA, showing to be a feasible and reproducible technique. However, there has not been a substantial success, and published cases so far do not reach more than 100, most of them being anecdotal case reports (Tables 7.1 and 7.2). When analyzing our initial experience in a series of eight cases [4], we found that SPAS takes longer and includes a number of

Table 7.1 Single-incision laparoscopic splenectomy. Literature review: single cases

Demographics	*N* (%)
Age (year)	23 (0.6–73)
Male/female	35/46
BMI (kg/m^2)	23 (18–36)
Diagnosis	
Splenomegaly	33 (45 %)
Idiopathic thrombocytopenic purpura	23 (31 %)
Immune thrombocytopenic purpura	5 (7 %)
Lymphomas	5 (7 %)
Splenic cysts	4 (5 %)
Traumatic rupture	2 (3 %)
Hydatic cyst	1 (1 %)
Multiple splenic abscesses	1 (1 %)
Spleen weight (g)	446 (125–590)
Operative parameters	
Port system applied	
2 or 3 single ports	43 (54 %)
SILS® port	21 (27 %)
TriPort®	6 (8 %)
Glove port	5 (6 %)
GelPort®	4 (5 %)
Size of incision (mm)	22 (10–35)
Outcomes	
Operative time (min)	125 (45–420)
Blood loss (ml) 50 (10–450)	
Conversion	4 (5 %)
Transfusion	11 (14 %)
Hospital stay (day)	3 (1–9)
Complications	6 (7)
Death	0
Positive cosmesis	42 (52 %)

controversies, such as (1) the placement of the device for SPAS, subcostal or umbilical. The subcostal placement facilitates the performance but obviously reduces the potential esthetic advantages. In the case of a pure umbilical approach, the esthetic result is maintained, but the difficulty increases to the point of becoming nearly impossible in the case of obese or very tall patients. (2) Several published series noted the need for some type of additional instrument to hold or expose surgical areas during SPAS. There have been uses of tugs [38], strings [30], or merely additional mini-instruments [4]. (3) Finally, in some cases, a drain is needed, and a left subcostal incision for drain placement may be required. All these factors and the current availability of dedicated instrumentation (deflectable scope) encouraged us to design a hybrid reduced port approach that could overcome some of the SPAS drawbacks, maintaining the clinical and esthetic advantages of an even less invasive minimal approach.

Table 7.2 Main characteristics and outcomes of patients after single-incision laparoscopic splenectomy, in published case series

Author/ year	Study type	*N*	Age (yrs)	BMI (kg/m^2)	Diagnosis	Device	Spleen weight (g)
Boone 2013 [35]	Retrospective comparative	LS, 18/26 (69 %); SILS, 8/26 (31 %)	LS, 49 ± 17; SILS, 51 ± 22 $p = 0.81$	LS,27 ± 5; SILS, 27 ± 8 $p = 0.98$	LS, malg (8/26 (31); ITP, 6/26 (23); AHAI, 2/26 (8 7.7); cyst, 1/26 (3.8); splenic infarction, 1/26 (3.8); SILS, malg. 3/26 (11.5); ITP, 2/26 (7.7); AHAI, 2/26 (7.7); cyst, 1/26 (3.8)	Gelpoint®	LS, 474 8 ± 332; SILS, 423 ± 444 $p = 0.77$
Choi 2013 [36]	Retrospective comparative	LS, 18/34 (53); SILS, 16/34 (47)	LS, 46 ± 20; SILS, 52 ± 13, $p = 1$	LS, 23 ± 2.6; SILS, 25 ± 4. 2 $p = 0.4$	LS: ITP, 11/34 (32)§; SILS: ITP, 9/34 (26)§	OCTO port®/ glove port	LS, 132 ± 72. SILS, 80 ± 38. $p = 0.1$
Perger 2013 [37]	Prospective, comparative	LS, 14/30 (47); SILS, 16/30 (53)	LS, 7 (2–17); SILS, 7 (1–15), $p = 0.44$	NR	LS: sphere. 6/30 (20), sickle cell dis./30 (17), ITP: 3/30 (10) SILS: spheroc. 8/30 (27), sickle cell dis. 4/30 (13), ITP: 3/30 (10), AHAI 1/30 (3)	QuadPort®	LS, 229 (62–1,145); SILS, 169 (49–536), $p = 0.86$
Monclova 2013 [4]	Prospective, comparative	LS, 14/32 (44); SILS, 8/32 (25); RPAS, 10/32 (31.2)	LS, 55 ± 18; SILS, 50 ± 19; RPAS, 41 ± 13, p = NS	LS, 28 ± 5; SILS, 25 ± 4; RPAS, 24 ± 4.5, p = NS	LS: ITP, 13/14 (93); AIHA, 1/14 (7); SILS: ITP, 3/8 (37); sph, 2/8 (25); malg, 3/8 (37); RPAS: ITP, 8/10 (80); AHAI, 1/10 (10); malg, 1/10 (10)	3 ports/ multi-access single port	LS, 212 ± 127; SILS, 394 ± 153; RPAS, 230 ± 87, $p = 0.02$
Misawa 2011 [38]	Prospect	10	53 (24–66)	NR	ITP, 3/10 (30); liver cirrhosis, 2/10 (20); aneurysm, 2/10 (20); cyst, 2/10 (20); tumor, 1/10 (10)	SILS port®	260 (100–580)

USA United States of America, *N* number, *NR* not referred, *BMI* body mass index, *yrs* years, *LS* laparoscopic splenectomy, *SILS* single-port access splenectomy, *RPAS* reduced port access splenectomy, *ITP* immune thrombocytopenic purpura, *Sph* spherocytosis, *Malg* malignant disease, *VAS* visual analog score, *NS* not statistically significant

Incision size	Duration (min)	Blood loss (ml)	Conversion (%)	Transfusion	Hosp. stay (day)	Complications	Cosmesis
40	LS, 186 ± 77; SILS, 102 ± 32 $p = 0.003$	LS, 399 ± 494; SILS, 79 ± 68, $p = 0.25$	LS, 5/26 (19); SILS, 0/26	LS, 6/26 (23); SILS, 2/26 (8 7)	LS, 5 ± 2.5; SILS, 4.4 ± 2.8, $p = 0.51$	LS, 5/26 (19); SILS, 2/26 (8)	NR
30	LS, 89 ± 21; SILS, 95 ± 32 $p = 0.6$	LS, 206 ± 142. SILS, 111 ± 99. $p = 0.04$	LS, 0/34; SILS, 0/34	LS, 1/34 (3); SILS, 1/34 (3)	LS, 5 ± 3; SILS, 5 ± 2, $p = 0.5$	LS, 2/34 (5.9); SILS, 1/34 (3)	NR
15	LS, 99 (51–154); SILS, 84 (40–190), $p = 0.89$	LS, 10 (5–60); SILS, 10 (5–600), $p = 0.61$	LS, 1/30 (3); SILS, 2/30 (6)	NR	LS, 2 (1–5); SILS, 2 (1–8), $p = 0.2$	LS, 2/30 (6); SILS, 3/30 (7)	NR
NR	LS, 83 ± 19; SILS, 131 ± 43; RPAS, 81 ± 22, $p = 0.01$	NR	LS, 0/14; SILS, 0/8; RPAS, 0/10	LS, 1/14 (7); SILS, 1/8 (12.5); RPAS, 0/10, $p = NS$	LS, 5 ± 3; SILS, 4 ± 2; RPAS, 3 ± 2, $p = NS$	NR	Body image index* LS, 7 ± 3; SILS, 6 ± 1; RPAS, 5 ± 0.4, $p < 0.02$
20	230 (150–378)	15 (0–100)	1/10 (10)	NR	6.8 ± 2.3	0/10	NR

In our experience comparing a series of cases operated by conventional laparoscopic approach, single-port splenectomy, or reduced port splenectomy, it is clearly shown that RPAS is a good alternative to LS and SPAS. RPAS had operative times comparable to that of LS and significantly shorter than SPAS. No patient was converted to open surgery in any group, but three patients required additional trocars to finish the SPA splenectomy. Blood loss and morbidity were similar in the three groups, as well as the clinical outcomes in terms of complications, reoperation, or stay.

Obviously, when analyzing the outcome after SPAS or RPAS, one of the main advantages in comparison to LS should be better postoperative comfort and esthetic results. Pain differences between conventional laparoscopy and SPA are a matter of controversy, observing contradictory results in the literature [40, 41]. In our study, we found no differences in relation to pain medication between the three groups. However, the nonrandomized nature of the study without a defined protocol to evaluate postoperative pain precludes establishing definitive conclusions.

Other aspects considered to be important after RPAS are the esthetic results and the possible avoidance of abdominal wall hernias, observed when large bore trocars are placed in the abdominal wall. It is noteworthy that after the analysis of the esthetic survey, all the three technical options were followed by a high degree of satisfaction, a finding that it is difficult to compare these techniques from the esthetic point of view. However, both SPAS and RPAS showed a significant improvement in the body image index in relation to LS, and these overall results allow us definitely to conclude that the reduction of the wound sizes has a small but positive impact on the perception of scars.

The evolution of minimally invasive surgery, looking for the utopic "non-scar surgery," obviously goes through more complex procedures with sophisticated tools. However, this philosophy may preclude the widespread acceptance of these techniques. RPAS permits to maintain the basic surgical features (triangulation) with similar clinical outcomes and better preservation of the abdominal wall. An additional issue is the cost. The technical option that we propose here can be afforded without increasing the overall expenditure, but obviously, it is best performed with the aid of more sophisticated surgical tools (deflectable scope).

According to Curcillo's beliefs [3], SPA surgery is not a "closed" concept. The technique that we have shown may be facilitated using a SPA device placed at the umbilicus adding other instrumentations through the umbilicus as needed, according to the experience of the surgeon.

References

1. Habermalz B, Sauerland S, Decker G et al (2008) Laparoscopic splenectomy: the clinical practice guidelines of the European Association for Endoscopic Surgery (EAES). Surg Endosc 22:821–848
2. Targarona E, Lima M, Balague C, Trias M (2011) Single-port splenectomy: current update and controversies. J Minim Access Surg 7:61–64
3. Curcillo PG 2nd, Podolsky ER, King SA (2011) The road to reduced port surgery: from single big incisions to single small incisions, and beyond. World J Surg 35:1526–1531

4. Monclova JL, Targarona EM, Vidal P et al (2013) Single incision versus reduced port splenectomy–searching for the best alternative to conventional laparoscopic splenectomy. Surg Endosc 27:895–902
5. Fan Y, Wu SD, Siwo EA (2011) Emergency transumbilical single-incision laparoscopic splenectomy for the treatment of traumatic rupture of the spleen: report of the first case and literature review. Surg Innov 18:185–188
6. Rottman SJ, Podolsky ER, Kim E et al (2010) Single port access (SPA) splenectomy. J Soc Laparoendosc Surg 14:48–52
7. Rhodes M, Rudd M, O'Rourke N et al (1995) Laparoscopic splenectomy and lymph node biopsy for hematologic disorders. Ann Surg 222:43–46
8. Barbaros U, Dinccag A (2009) Single incision laparoscopic splenectomy: the first two cases. J Gastrointest Surg 13:1520–1523
9. Barbaros U, Sumer A, Tunca F et al (2010) Our early experiences with single-incision laparoscopic surgery: the first 32 patients. Surg Laparosc Endosc Percutan Tech 20:306–311
10. Bell R, Boswell T, Hui T et al (2012) Single-incision laparoscopic splenectomy in children. J Pediatr Surg 47:898–903
11. Chinnusamy P, Ahluwalia JS, Palanisamy S et al (2013) Single incision multi-trocar hepatic cyst excision with partial splenectomy. J Minim Access Surg 9:91–94
12. Colon MJ, Telem D, Chan E et al (2011) Laparoendoscopic single site (LESS) splenectomy with a conventional laparoscope and instruments. J Soc Laparoendosc Surg 15:384–386
13. Dapri G, Bron D, Himpens J et al (2011) Single-access transumbilical laparoscopic splenectomy using curved reusable instruments. Surg Endosc 25:3419–3422
14. Dapri G, Casali L, Bruyns J et al (2010) Single-access laparoscopic surgery using new curved reusable instruments: initial hundred patients. Surg Technol Int 20:21–35
15. Dutta S (2009) Early experience with single incision laparoscopic surgery: eliminating the scar from abdominal operations. J Pediatr Surg 44:1741–1745
16. Ergun O, Tiryaki S, Celik A (2011) Single center experience in single-incision laparoscopic surgery in children in Turkey. J Pediatr Surg 46:704–707
17. Garey CL, Laituri CA, Ostlie DJ et al (2011) Single-incision laparoscopic surgery in children: initial single-center experience. J Pediatr Surg 46:904–907
18. Garrett D, Emami C, Anselmo DM et al (2011) Single-incision laparoscopic approach to management of splenic pathology in children: an early experience. J Laparoendosc Adv Surg Tech A 21:965–967
19. Hansen EN, Muensterer OJ (2010) Single incision laparoscopic splenectomy in a 5-year-old with hereditary spherocytosis. J Soc Laparoendosc Surg 14:286–288
20. Ismail E, Akyol C, Basceken SI et al (2012) Glove port single-incision laparoscopic splenectomy and the treatment of its complications. Clinics (Sao Paulo) 67:1519–1521
21. Jing K, Shuo-Dong W, Ying F (2013) Transumbilical single-incision laparoscopy surgery splenectomy plus pericaudial devascularization in one case with portal hypertension: the first report. Surg Innov 20(6):NP21–NP24
22. Joshi M, Kurhade S, Peethambaram MS et al (2011) Single-incision laparoscopic splenectomy. J Minim Access Surg 7:65–67
23. Malladi P, Hungness E, Nagle A (2009) Single access laparoscopic splenectomy. J Soc Laparoendosc Surg 13:601–604
24. Oyama K, Sasaki A, Chiba T et al (2011) Single-incision laparoscopic splenectomy for idiopathic thrombocytopenic purpura: report of a case. Surg Today 41:1091–1094
25. Pedziwiatr M, Matlok M, Major P et al (2013) Laparoscopic surgery of the spleen through single umbilical incision. Wideochir Inne Tech Malo Inwazyjne 8:8–12
26. Podolsky ER, Curcillo PG 2nd (2010) Single port access (SPA) surgery–a 24-month experience. J Gastrointest Surg 14:759–767
27. Taher R, Tawfeeq M (2011) Single-port laparoscopic splenectomy for idiopathic thrombocytopenic purpura. Ann Saudi Med 31:655–656
28. Tam YH, Lee KH, Chan KW et al (2010) Technical report on the initial cases of single-incision laparoscopic combined cholecystectomy and splenectomy in children, using conventional instruments. Surg Innov 17:264–268

29. Tam YH, Lee KH, Sihoe JD et al (2010) Initial experience in children using conventional laparoscopic instruments in single-incision laparoscopic surgery. J Pediatr Surg 45:2381–2385
30. Vatansev C, Ece I Jr (2009) Single incision laparoscopic splenectomy with double port. Surg Laparosc Endosc Percutan Tech 19:e225–e227
31. Wu SD, Fan Y, Kong J et al (2013) Transumbilical single-incision laparoscopic splenectomy plus pericardial devascularization using conventional instruments: initial experience of 5 cases. J Laparoendosc Adv Surg Tech A 23:150–153
32. Hong TH, Lee SK, You YK et al (2010) Single-port laparoscopic partial splenectomy: a case report. Surg Laparosc Endosc Percutan Tech 20:e164–e166
33. You YK, Lee SK, Hong TH et al (2010) Single-port laparoscopic splenectomy: the first three cases. Asian J Endosc Surg 3:33–35
34. Sharma A, Dahiya P, Khullar R et al (2012) Single-Incision Laparoscopic Surgery (SILS) in biliary and pancreatic diseases. Indian J Surg 74:13–21
35. Boone BA, Wagner P, Ganchuk E et al (2013) Single-incision laparoscopic splenectomy: preliminary experience in consecutive patients and comparison to standard laparoscopic splenectomy. Surg Endosc 27:587–592
36. Choi KK, Kim MJ, Park H et al (2013) Single-incision laparoscopic splenectomy versus conventional multiport laparoscopic splenectomy: a retrospective comparison of outcomes. Surg Innov 20:40–45
37. Perger L, Aprahamian CJ, Muensterer OJ et al (2013) Single-incision pediatric endosurgery (SIPES) splenectomy: a case-control series. J Laparoendosc Adv Surg Tech A 23:162–165
38. Misawa T, Sakamoto T, Ito R et al (2011) Single-incision laparoscopic splenectomy using the "tug-exposure technique" in adults: results of ten initial cases. Surg Endosc 25:3222–3227
39. Fan Y, Wu SD, Kong J, Su Y, Tian Y, Yu H (2014) Feasibility and safety of single-incision laparoscopic splenectomy: a systematic review. J Surg Res 186:354–362
40. Ma J, Cassera MA, Spaun GO, Hammill CW, Hansen PD, Aliabadi-Wahle S (2011) Randomized controlled trial comparing single-port laparoscopic cholecystectomy and four-port laparoscopic cholecystectomy. Ann Surg 254:22–27
41. St Peter SD, Adibe OO, Juang D, Sharp SW, Garey CL, Laituri CA, Murphy JP et al (2011) Single incision versus standard 3-port laparoscopic appendectomy: a prospective randomized trial. Ann Surg 254:586–590

Single-Access Laparoscopic Right Hemicolectomy

8

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Since the first laparoscopic colonic resection was reported in the early 1990s, laparoscopic colorectal surgery has evolved as skills, experience, and, not less important, technology have advanced tremendously.

Perfect standardization of the surgical technique, advanced instruments for dissection and coagulation, and modern laparoscopes with digital elaboration of the image have driven to a reduced number of ports and instruments needed. This trend toward making colorectal surgery more pleasing cosmetically has been further stimulated by the introduction of NOTES (natural orifice transluminal endoscopic surgery). However, the initial enthusiasm for this approach had to be faced with many drawbacks, particularly the requiring of an expensive and specialized equipment, longer operating time, extensive further training even for experienced laparoscopic surgeons, use of additional ports for introducing stapling devices, and also ethical issues concerning the access through the internal viscera or structures that have no direct relations to the targeted organ [1]. As matters stand, NOTES colectomy probably has no clinical application [2].

As an alternative to this technique, single-incision laparoscopic surgery (SILS) uses the umbilicus as an embryonic natural orifice to access the abdominal cavity, promising to be an almost scarless procedure. SILS technique overcomes some of the drawbacks of NOTES as it can be performed without the need of special instruments and requires a single incision (the umbilicus or the ostomy site) that can be used for the extraction of the specimen.

Since 2009, an explosion of publications on the topic of single-port colorectal surgery has occurred, as shown in Fig. 8.1 [3]. However, despite the growing amount

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_8, © Springer International Publishing Switzerland 2014

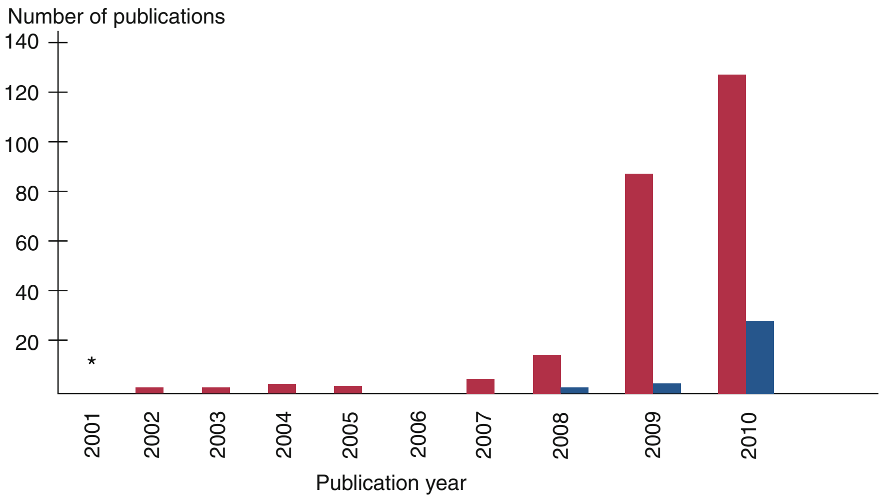

Fig. 8.1 The rate of publication on the topic of single-port laparoscopic surgery has increased drastically in all surgical disciplines (*red*) and in colon and rectal surgery (*blue*) (Reprinted from [3])

of data published, the experience in any given series remains limited with most of the study being case series and no randomized trial on the topic. In other words, although single-incision laparoscopic colectomy (SILC) is widely promoted, outcome data are virtually absent [4].

In this chapter, we will describe the surgical technique but also data arising from the literature about the real benefits the technique is expected to bring to the patients.

8.1 Anesthesia for Laparoscopy

The physiological changes associated with the creation of a pneumoperitoneum and positioning of the patient during laparoscopy must be appreciated and compensated for, to avoid complications and adverse outcome, which may have an insidious onset.

Laparoscopic surgery has been traditionally contraindicated in patients with severe ischemic disease, valvular disease, and significant renal dysfunction or end-stage respiratory disease. Nowadays, absolute contraindications to the laparoscopic approach are limited to raised intracranial pressure, severe uncorrected hypovolemia, and acute heart failure. An accurate preoperative balance between the advantages of the laparoscopic approach and intraoperative risks is crucial to maximize the benefits of the technique [5].

8.1.1 Conduct of Anesthesia

The safer technique for airway management involves placement of a cuffed oral tracheal tube, neuromuscular relaxation, and positive-pressure ventilation. It is recommended that mask ventilation before intubation should be minimized to avoid gastric distension. The insertion of a nasogastric tube may be required not only to deflate the stomach but also to reduce the incidence of postoperative nausea and vomiting that can be very distressing for the patients [6]. The use of the laryngeal mask airway remains controversial. Locoregional anesthesia is limited to selected cases [7].

8.1.2 Ventilation

Traditional volume control modalities use constant flow to deliver a preset tidal volume and ensure an adequate minute volume at the expense of an increased risk of barotrauma and high inflation pressure. The use of pressure-controlled modalities minimizes peak pressure and has been shown to provide improved areolar recruitment and oxygenation [8]. The mean airway pressure (Paw), both the highest airway pressure (peak) and the airway pressure during the plateau phase, must always be less than 30 cm H_2O in order to avoid ventilatory-induced lung injury (VILI). In fact, in case of rise in PCO_2, ventilation strategy must be adapted to the patient, preferring an increase of the respiratory rate and limiting tidal volume and insufflation pressure. Translating the concept of lung-protective ventilatory strategy from the adult respiratory distress syndrome context, the application of “an open lung” strategy consisting of a recruiting maneuver followed by the subsequent application of positive end-expiratory pressure (PEEP) has been suggested to effectively reexpand pneumoperitoneum-induced atelectasis and improve oxygenation during laparoscopic surgery [9].

8.1.3 Analgesia

By the nature of minimally invasive surgery, the pain is often short, yet intense, requiring opioid analgesia at some stage perioperatively. The use of systemic drugs (FANS and paracetamol), regional technique such as subdural, epidural, and more recently transversus abdominis plane block (TAP block), together with wound infiltration with local anesthetic are increasingly used as opiate-sparing techniques [10].

8.1.4 Monitoring

Standard monitoring during laparoscopic surgery does not differ from open surgery and includes noninvasive monitoring of blood pressure (NIBP), ECG, control of the neuromuscular block (TOF), bispectral analysis (BIS) for assessing the depth of the hypnotic component of anesthesia, end-tidal CO_2 ($EtCO_2$), and SaO_2, supported by information available on modern anesthetic machines such as peak and plateau airway pressures and dynamic flow-volume loops.

Most anesthetists advocate the use of invasive arterial monitoring, particularly in those patients with cardiovascular comorbidities, which allows continuous analysis of arterial blood gas (ABG). In selected cases, due to the poor value of the central venous pressure in the assessment of preload, other devices such as esophageal Doppler monitor (EDM), transesophageal echocardiography, the Vigileo, and the PiCCO systems can be used to monitor cardiac output (CO) of the patients. Those methods are recently replacing the insertion of a pulmonary artery catheter in an attempt to reduce iatrogenic complications and improve the ease of CO monitoring.

The PiCCO system (pulse contour cardiac output) is based on a transpulmonary thermodilution curve and allows continuous monitoring of the CO as well as monitoring of the global end-diastolic volume (GEDV) and of the extravascular lung water (EVLW).

The Vigileo system (Vigileo, Edwards LLC) analyzes the entire arterial waveform, and it does not necessarily require a central line. Furthermore, it does not require an initial calibration and allows continuous monitoring of the CO, the stroke volume (SV), the systemic vascular resistance (SVR), and the stroke volume variation (SVV) which represents an important index of preload and of patient's response to fluids.

NICOM (noninvasive cardiac output monitoring) (Cheetah Medical, Tel Aviv) is based on bioreactance measurements through external sensors positioned on patient's chest. Through this fully noninvasive method, continuous monitoring of CO, SV, SVV, and total peripheral resistance (TPR) is possible.

Those systems have great importance also for tailoring intraoperative intravenous fluid administration [11], as fluid restriction in colorectal surgery has been demonstrated to reduce the rate of postoperative complications in randomized trials [12].

8.2 Surgical Technique

The procedure is performed with the patient under general anesthesia, with endotracheal intubation. At surgery, prophylactic intravenous antibiotics are administered. Pneumoboots are placed bilaterally in the operative room and activated before induction. The pneumoboots remain in place until the patients are ambulating. Deep vein thrombosis prophylaxis is started 6 h after the end of the operation, prolonged during the entire hospital stay, and discontinued at home at different time interval depending on the underlying disease (benign or malignant).

The patient lies in supine position, the table is 30° tilted leftward, while the surgeon and the assistant stand at the left side of the patient, the latter holding the camera at the head of the patient. The laparoscopic track is positioned in front of the surgeons, while the scrub nurse can stay between the patient's legs or at the left side of the surgeon (Fig. 8.2).

Fig. 8.2 Operative room setup

Access to the peritoneal cavity is obtained through a skin incision of about 25–30 mm either right around the upper edge of the umbilicus or dividing longitudinally the umbilicus itself. In this case, the umbilicus is grasped at its base and everted. A 25-mm fascial incision is made, the peritoneum is entered, and the single-incision laparoscopic system (SILS) port (Covidien, Norwalk, CT, USA) or the TriPort system (Olympus Surgical and Industrial America Inc., Center Valley, PA) is placed into the peritoneal cavity. Those ports include an insufflation attachment and, respectively, three or four access ports, which can be used for 12-mm and 5-mm trocars. Pneumoperitoneum is then established. Standard non-articulated instruments are generally introduced through the single-access device: a 5-mm 30° scope, and two 5-mm working instruments, usually a Johanne forceps and an energized device. The use of 30° scope is strongly recommended to keep the camera out of line with the operating surgeon's instruments. Also a 5-mm flexible-tip high-definition laparoscope (Olympus KeyMed, Southend, UK) or a bariatric length camera could provide better ergonomics to the surgeon and better facilitation of camera operation.

Thirty-degree 10-mm optic can be used as well, but this will further reduce the working room and it will have to be replaced by a 5-mm optic when utilizing the stapler.

During dissection, the grasper and the energized device change port to ensure the best angle.

Fig. 8.3 The ileocolic pedicle is exposed by the traction exerted by the left hand on the ileocolic junction

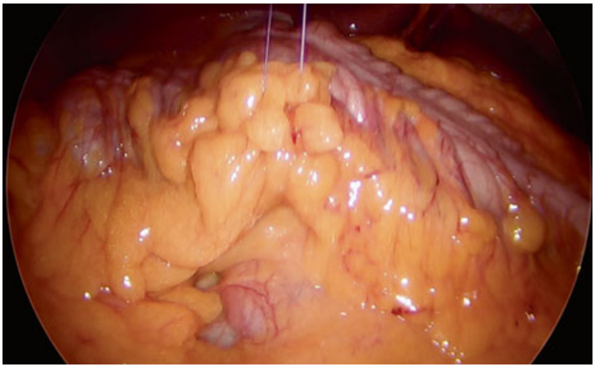

Fig. 8.4 Transverse colon lifted up by a stay suture

Initial laparoscopic exploration is performed, and the patient is then placed in a 20° Trendelenburg position. The ileocolic pedicle is exposed retracting the ileocolic junction with the left hand (Fig. 8.3). To facilitate the visualization of the ileocolic pedicle, especially in obese patients, a stay suture introduced through the abdominal wall with a straight needle can be positioned to lift up the transverse colon (Fig. 8.4).

Once the ileocolic pedicle is identified, it is lifted up to allow the opening of a window beneath the vessels, thus identifying the duodenum (Fig. 8.5). A medial-to-lateral dissection between Toldt and Gerota's fascia is performed both with the use of an energy device and with the aid of a small swab. We have to remember, in fact, that this plane is a completely avascular plane and no vascular connection exists between the visceral mesentery and the retroperitoneal plane (Fig. 8.6). Thus, when dissecting this plane, one must be aware that the presence of a bleeding means that dissection is being conducted in the wrong plane. It may be useful to remember that when you go in the wrong plane, you are almost always going too posteriorly, putting retroperitoneal structures (e.g., ureter and gonadal vessels) at risk of injury.

When the retroperitoneal plane is completely dissected free and the duodenum is well visualized in the field, the ileocolic pedicle can be sealed either by the LigaSure

Fig. 8.5 The duodenum is visible in the field

Fig. 8.6 A window is opened beneath the ileocolic vessels and a medial-to-lateral dissection is performed between Toldt and Gerota's fasciae

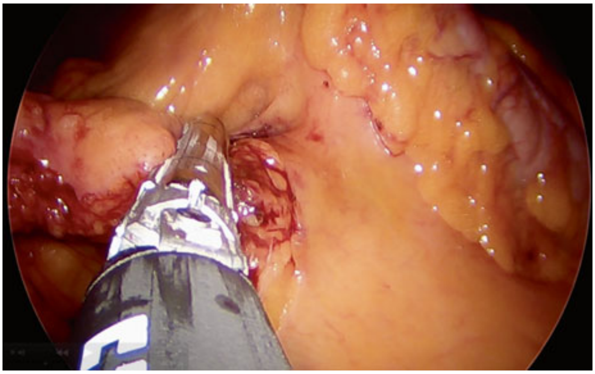

Fig. 8.7 Section of the ileocolic pedicle

Advance (Covidien, Mansfield, MA, USA), the application of clips, or by the use of an Endo GIA loaded with a white cartridge (Figs. 8.7 and 8.8).

The cecum is then mobilized, the lateral attachments are dissected free, and the mesentery is divided up to the terminal ileum, which is then sectioned with an Endo GIA (Figs. 8.9 and 8.10).

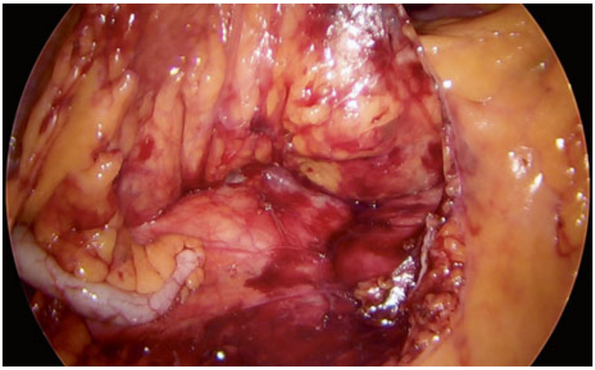

Fig. 8.8 The staple line sealing the ileocolic vessels is well visible in the field with the duodenum and the Gerota's fascia

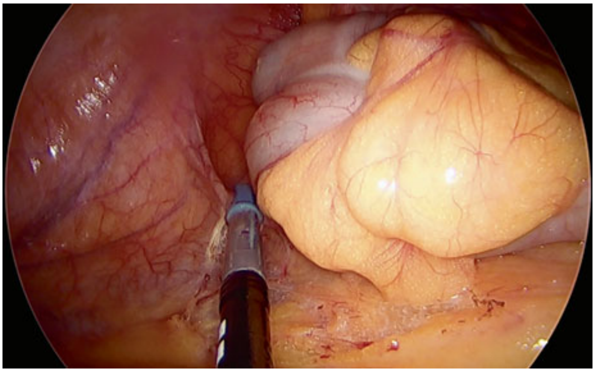

Fig. 8.9 The cecum and the ascending colon are mobilized by cutting the lateral attachments. Please note in this case that the dissecting instrument is in the left hand while the traction is performed with the right hand of the surgeon

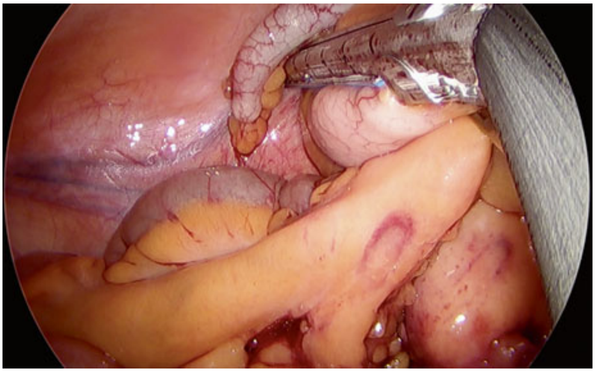

Fig. 8.10 The terminal ileum is transected with an Endo GIA

To visualize the hepatic flexure, the grasper in the left hand can sweep the right colon medially and anteriorly which will display the hepatocolic attachments and the duodenum. Once the hepatic flexure is mobilized, the omentum attached to the specimen is divided. The transverse colon is sectioned using an endoscopic linear stapler, and the specimen can be positioned in an endobag to be removed through the same umbilical incision together with the access device. A side-to-side extracorporeal anastomosis is then performed up to surgeon's preference. Alternatively, the specimen is positioned on the right lobe of the liver in an endobag, and a side-to-side ileocolic anastomosis is fashioned by mechanical stapling, closing the defect with interrupted stitches tied extracorporeally.

If previously removed, the access device is then reinserted to allow inspection of the peritoneal cavity and careful hemostasis. The fascial defect is then closed using interrupted absorbable sutures.

8.3 What We Know

Up to date, all data emerging from the literature support the idea that right colectomy with the single-access technique is not only feasible, but it is probably, together with total colectomy with end ileostomy, most clearly suited to single-port procedure, as it mandates an extraction site of equivalent size to a single-port apparatus. In fact in a recent article, Costedio and Remzi, the first who described a single-port right colectomy [13], stated that colorectal surgery is a natural place for single-access surgery and, as technology advances, it is likely that there will be a niche that benefits from single-port laparoscopy [14].

The theoretical benefits of SILC include improved cosmesis, decreased pain, and shorter length of stay.

Randomized trial and meta-analysis in single-access laparoscopic cholecystectomy failed to demonstrate a reduction in postoperative pain compared to conventional laparoscopic cholecystectomy [15–17], but data are lacking in the colorectal literature. Furthermore, in the authors' opinion, it could be very difficult, even in properly conducted randomized trial, to demonstrate a significant reduction of pain when comparing right SILC with conventional 3-port laparoscopic right colectomy.

Despite the lack of data, all the published studies [18–34] suggest that SILC is feasible and safe and has short-term and oncologic outcome (in terms of free margins and number of nodes harvest) comparable to multiport laparoscopy.

We will briefly analyze the published data to discuss if and how those data support this statement.

We were able to analyze the results of 11 case-controlled series, published between 2010 and 2013 [18–28]. The results of those series are shown in Table 8.1. There were 361 SILS procedures compared with 510 conventional multiport colectomies (CMC). Rate of conversion from SILS to multiport laparoscopy was 5.8 % (21 cases), whereas conversion to open surgery occurred in only 1.3 % of the whole series (five patients). Rate of conversion to open surgery in the CMC was 4.5 % (23 patients).

Morbidity rate was 15.8 % (57/361) in the SILS group vs. 20.3 % (104/510) in the CMC group.

Mortality rate was 0.6 % (two deaths) vs. 1.4 % (seven deaths) in SILS and CMC groups, respectively.

Length of hospital stays was 5.1 days (range 2–41) in the SILS patients vs. 5.9 (range 2–109) in the CMC patients. Operative time was 140′ and 145.7′ (range from

Table 8.1 From 11 case-controlled series published between 2010 and 2013, 361 SILS procedures are compared with 510 CMC

	SILC									
Authors	N°	Exclusion criteria	Conversion (port added/open surgery)	LOS	Operative time	Mortality	Morbidity	Age	BMI	Device
Rosati et al. [19]	50	Tumor >3,5 cm, contraindications to laparoscopic surgery	0	6*** (4–16)	160 (115–210)	0	8 %****(4/50)	65 (36–88)	nr	Endocone
Chew et al. [20]	40	Emergency	3 2	5 (4–15)	95 (45–180)	0	23 % (9/40)	63 (41–84)	22.3 (16.1–34.9)	SSL (53 %) SILS (2 %)
Yun et al. [18]	66	Benign disease	0 1	8 ± 4 (5–27)	155 ± 45******* (97–455)	Not clear[a]	9.1 % (6/66)	61 ± 11 (33–80)	23.82 ± 2.81 (18.5–31.9)	Handmade glove port
Egi et al. [25]	10	None	0 0	8** (6–13)	192 (156–231)	0	0	68.5 (61–81)	22.5 (19.6–24.6)	GelPort
Velthuis et al. [22]	50	None	2 0	6 (2–41)	97****** (60–148)	1	34 % (17/50)	73 ± 13.2	25 (20–32)	SILS TriPort
Kanakala et al. (20 right,11 left colectomy 3 AR 8 other interventions) [21]	40	Rectal cancer. At the beginning (?) high BMI and malignant disease	3 0	4 (2–11)	162′	0	7.5 % (3/40)	54.1 (17–86)	26.2 (18–37)	Different devices
McNally et al. (14 right, 5 transverse, 8 left colectomies) [28]	27	No evidence of adjacent organ involvement Few or no previous abdominal operations	5 0	3 (2–17)	114 (59–268)	0	18.5 % (5/27)	67 (26–86)	27 (18.3–39.9)	SILS GelPort SSLPort

Chen et al. [24]	18	Colonic obstruction, perforation, prev. abdominal surgery	2 1	5 (3–15)	175 (145–280)	0	16.6 % (3/18)	69.4	23.34 (18.2–28.6)	Surgical glove
Lai et al. [26]	14	None	0 0	3,5 (2–5)	120 (90–135)	0	0	72 (20–90)	24 (21–27)	Quad port
Champagne et al. (19 right, 10 left) [23]	29	BMI >35, history of peritonitis, emergency operation	4 1	3.7	134.4*****	0	17 % (5/29)	61.2 ± 4.5 (25–93)	27.4	SILS port
Adair et al. [27]	17	Pregnancy Multiple previous abdominal surgeries BMI <30	2 0	3.9	139	1	29 % (5/17)	66.6 ± 10	26.2 ± 4.3	GelPort (3) GelPOINT (5) SILS (8) TriPort (1)
Total	361		21 (5.8 %) 5 (1.3 %)	5.1 (2–41)	140 (45–455)	2 (0.6 %)	57 (15.8 %)	65.5 (17–93)	24.7	

(continued)

Table 8.1 (continued)

	Conventional laparoscopy									
Authors	N°	Exclusion criteria	Conversion	LOS	Operative time	Mortality	Morbidity	Age	BMI	N° of ports
Rosati et al. [19]	50	Contraindications to laparoscopic surgery	2	8*** (4–34)	152 (110–215)	2 % (1/50)	22 %****(11/50)	65 (44–87)	nr	nr
Chew et al. [20]	104	Emergency	7	5 (3–109)	100 (55–190)	1	20 % (21/104)	67 (23–88)	23.1 (14–36.6)	3/4
Yun et al. [18]	93	Benign disease	5	9 ± 5 (4–36)	174 ± 56******* (67–393)	Not clear[a]	15.1 % (14/93)	59 ± 11 (30–80)	24.23 ± 2.70 (17.1–31.6)	5
Egi et al. [25]	10	None	1	10.5** (7–21)	222 (44–244)	0	0	68 (33–84)	21.9 (17.1–26.2)	5
Velthuis et al. [22]	50	n.s.	0	6 (2–103)	112****** (70–225)	2	34 % (17/50)	71 ± 11.8	25 (20–36)	3
Kanakala et al. (20 right,11 left colectomy 3 AR 8 other interventions) [21]	78	No rectal cancer included in the comparison	0	4 (2–20)	170	1.3 % (1/78)	12.8 % (10/78)	64.8 (23–84)	28.0 (21–45)	nr
McNally et al. (14 right, 5 transverse, 8 left colectomies) [28]	46	Additional procedures	6 (13 %)	5 (2–11)	135 (45–314)	4.3 % (2/46)	35 % (16/46)	73 (48–92)	26	3/4

Chen et al. [24]	21	n.s.	0	5 (3–38)	165 (120–340)	0	19 % (4/21)	66.1	23.92 (19–30.4)	4
Lai et al. [26]	12	n.s.	0	4 (3.8–7)	135 (116–150)	0	0	69 (16–82)	28.5 (27–33.5)	nr
Champagne et al. (19 right, 10 left) [23]	29	n.s.	2 (7 %)	3.9	103.8*****	0	24 % (7/29)	63.5 ± 5.2 (20–89)	28.8	4
Adair et al. [27]	17	n.s.	0	4.1	134		24 % (4/17)	66.7 ± 13	25.2 ± 5.0	3
Total	510		23 (4.5 %)	5.9 (2–109)	145.7 (45–393)	7 (1.4 %)	104 (20.3 %)	66.6	22.5	

nr not reported, *n.s.* not specified

*$p < 0.001$; **$p = 0.023$; ***$p < 0.0001$; ****$p = 0.005$; *****$p = 0.002$; ****** $p < 0.001$; ******* $p = 0.015$

[a]Authors stated: "no perioperative mortality related to surgery itself occurred"

45′ to 455′ vs. 45′ to 393′) in SILS and CMC respectively. Those data have been recently confirmed in a systematic review and meta-analysis performed by Vettoretto et al. in which nine studies fulfilling the inclusion criteria were analyzed. No statistically significant difference was found between the two techniques in overall morbidity (14.6 % vs. 16.3 % in SILS and CMC) or in overall mortality (0.82 % SILS vs. 1.16 % CMC). No difference was found in the operation time (although data were insufficient for meta-analysis), whereas data on the length of postoperative stay were insufficient for a pooled analysis. Conversion rate to open surgery was 1.71 % in the SILS group vs. 3.18 % in the CMC group. Similarly, there was no statistically significant difference in the number of lymph nodes harvested between the groups [35].

The main clinic message coming from those data is that SILS is not only feasible but even safer than conventional laparoscopy (0.5 % mortality rate and 13 % of morbidity rate), needs less operating time, and allows for a quicker recovery without compromising the quality of the oncologic resection (the mean number of harvested nodes as well as margin status did not show any significant difference in all the studies). Although this might seem a clear message, we must look inside those data before offering this approach to our patients routinely.

Three studies reported the length of skin incision that was found to be longer in the conventional laparoscopy group than in the SILS group (3.0 cm vs. 5.0 cm and 3.8 vs. 4.5 cm, 3.8 vs. 5.1 cm in the SILS and CMC, respectively, in EGI et al. and Champagne et al. and Adair et al. study) [23, 25, 27]. Rosati et al., in their article on 50 SILS matched with 50 conventional multiport laparoscopy, reported that the approach to SILS or CMC was chosen according to the estimated tumor diameter at preoperative CT scan (less than 3.5 cm in the SILS group) [19]. It has become clear that the umbilical incision size is dictated primarily by the size of the colon and tumor being removed [3], which means that patients operated with CMC technique must have had greater tumor. In the study of Chew et al., no difference was found in tumor size between the two groups, and in fact no significant difference was reported in the length of skin incision [20].

In 2011 Ross et al. published a multi-institutional experience of 39 cases of SILS colectomy. The operating surgeons, all experts in the field of laparoscopic colorectal surgery, were asked to compare the impression of SILS with multiport colectomy, which was summarized as "overall ease of the case," into three category: "easier than CMC," "same of CMC," and "harder than CMC." No cases were felt to be "easier than CMC." Overall operative safety was judged same as CMC by 84 % and harder than CMC by 16 % by participating surgeons. Variables identified that had statistically high scores with SILC than with CMC (meaning SILS is more difficult than CMC) included exposure of critical structures, ease of instruments, ease of camera operation, flexure mobilization, and instrument conflict. Those data are of great interest because patient and case selection was left to the discretion of each individual surgeon [4].

As evidenced by this evaluation of metrics, even in a cohort of surgeons with advanced skill, how can we explain a shorter operating time with SILS technique? This is probably an effect of a selection bias toward more favorable cases selected for the SILS approach in retrospective analyses.

Another important concern in adopting any new technique or technology is the learning curve. Many authors noted that the learning curve is little for experienced surgeons [34, 36]. Recently, Hopping and Bardakcioglu have specifically studied the learning curve for SILS finding that mean operative time and length of postoperative stay were significantly different between the first ten cases and second ten cases, so it seems that for SILS, the learning curve is flat for experienced laparoscopic surgeons [37].

Many authors reporting on SILS procedures claim a cosmetic benefit and a reduction of pain in this procedure. Interestingly, the only study, which reported the duration of narcotic use, did not find significant disparities. Demonstrating those benefits in the setting of a retrospective study would be challenging.

Only Yun et al. reported the short-term oncologic outcome. The disease-free survival at 24 months was 89.7 % in the SILS group vs. 96.3 % in the CMC ($p=0.12$) [18].

At this point, any advantages of this novel approach in right colon resection remain theoretical, and we were not able to find evidence suggesting that this approach is in any way superior to conventional multiple-port laparoscopy, although this question warrants further study in a prospective fashion.

8.4 Comments

Successful implementation of any surgical procedure relies on processes that will safely decrease morbidity to a minimum, avoid consumption of expensive medical resources, and can be adopted by a large number of surgeons [38].

It is logical to propose a consistent change in the laparoscopic approach when the uptake of laparoscopic surgery is so slow that nowadays less than 30 % of colorectal resections are performed laparoscopically in Western countries? [39].

The benefits reaped by SILS colectomy patients do not seem to outweigh the procedural difficulties faced by the surgeon. To maximize the benefits of the technique, patients must be selected carefully as not every individual may be a candidate for SILS. Visceral obesity can make the exposure of critical structures difficult if retraction cannot be appropriately obtained. This is in fact one of the main reasons reported in the literature for conversion to conventional laparoscopy.

Also bulky tumors are probably better treated by a conventional approach with an appropriate, cosmetic, Pfannenstiel incision used to extract the specimen.

Finally, it seems that SILS approach may predispose more toward extracorporeal anastomosis via the extraction site. In the literature, reported advantages of the intracorporeal anastomosis are represented by lesser postoperative pain and analgesia requirement with enhanced postoperative recovery [40], almost the same advantages expected by SILS.

Currently, eminence-based opinion suggests that SILS can be an alternative surgical technique, but a true, prospective analysis comparing standard of care and this "new" approach has yet to be published. However, there is no evidence in the literature that SILS colectomy confers any disadvantage to the patients over conventional laparoscopic surgery and, to date, there are no reports of SILS putting patients at increased risk of complications.

The Silverman1 prospective randomized trial will address most of the open issues concerning pain reduction and cosmesis, which are the postulated benefits of SILS colectomy over conventional laparoscopic colectomy. This trial started in July 2011 and will be completed on July 2016, with an estimated enrolment of 300 patients [41].

In the meanwhile, we do not think that SILS is just a "new toy for boys," as laparoscopy was nicknamed at its beginning 25 years ago, but rather a derivation of laparoscopic surgery that in selected cases can be a more pleasing cosmetic alternative to offer to our patients [42].

References

1. Lirici MM, Califano AD, Angelini P, Corcione F (2011) Laparo-endoscopic single site cholecystectomy versus standard laparoscopic cholecystectomy: results of a pilot randomized trial. Am J Surg 202:45–52
2. Chambers WM, Bicsak M, Lamparelli M, Dixon AR (2011) Single-incision laparoscopic surgery (SILS) in complex colorectal surgery: a technique offering potential and not just cosmesis. Color Dis 13:393–398
3. Waters JA, Rapp BM, Guzman MJ, Jester AL, Selzer DJ, Robb BW, Johansen BJ, Tsai BM, Maun DC, George VV (2012) Single-port laparoscopic right hemicolectomy: the first 100 resections. Dis Colon Rectum 55:134–139
4. Ross H, Steele S, Whiteford M, Lee S, Albert M, Mutch M, Rivadeneira D, Marcello P (2011) Early multi-institution experience with single incision laparoscopic colectomy. Dis Colon Rectum 54:187–192
5. Hayden P, Cowman S (2011) Anaesthesia for laparoscopic surgery. Contin Educ Anaesth Crit Care Pain 11:177–180
6. Perrin M, Fletcher A (2004) Laparoscopic abdominal surgery. Contin Educ Anaesth Crit Care Pain 4:107–110
7. Lim Y, Goel S (2007) Proseal is effective alternative to laryngoscope guided tracheal intubation. Contin Educ Anaesth Crit Care Pain 35:52–56
8. Valenza F, Chevallard G, Fossali T, Salice V, Pizzocri M, Gattinoni L (2010) Management of mechanical ventilation during laparoscopic surgery. Best Pract Res Clin Anaesthesiol 24:227–241
9. Cinnella G, Grasso S, Spadaro S, Rauseo M, Mirabella L, Salatto P, De Capraris A, Nappi L, Greco P, Dambrosio M (2013) Anesthesiology 118:114–122
10. Conaghan P, Maxwell-Armstrong C, Bedforth N (2010) Efficacy of transversus abdominis plane blocks in laparoscopic colorectal resections. Surg Endosc 24:2480–2484
11. Bundgaard-Nielsen M, Holte K, Secher NH, Kehlet H (2007) Monitoring of peri-operative fluid administration by individualized goal-directed therapy. Acta Anaesthesiol Scand 51:331–340
12. Abraham-Nordling M, Hiern F, Pollack J, Prytz M, Borg T, Kressner U (2012) Randomized clinical trial of fluid restriction in colorectal surgery. Br J Surg 99:186–191
13. Remzi FH, Kirat HT, Kaouk JH, Geisler DP (2008) Single-port laparoscopy in colorectal surgery. Color Dis 10:823–826
14. Costedio MM, Remzi FH (2013) Single-port laparoscopic colectomy. Tech Coloproctol 17(Suppl 1):S29–S34
15. Zehetner J, Pelipad D, Darehzereshki A, Mason R, Lipham JC, Katkhouda N (2013) Single access laparoscopic cholecystectomy versus classic laparoscopic cholecystectomy: a system-

atic review and meta-analysis of randomized controlled trials. Surg Laparosc Endosc Percutan Tech 23(3):235–243
16. Pisanu A, Reccia I, Porceddu G, Uccheddu A (2012) Meta-analysis of prospective randomized studies comparing single-incision laparoscopic cholecystectomy (SILC) and conventional multiport laparoscopic cholecystectomy (CMLC). J Gastrointest Surg 16:1790–1801
17. Hao L, Liu M, Zhu H, Li Z (2012) Single-incision versus conventional laparoscopic cholecystectomy in patients with uncomplicated gallbladder disease: a meta-analysis. Surg Laparosc Endosc Percutan Tech 22(6):487–497
18. Yun JA, Yun SH, Parl YA, Cho YB, Kin HC, Lee WY, Chun HK (2013) Single incision laparoscopic right colectomy compared with conventional laparoscopy for malignancy. Assessment of perioperative and short-term oncolic outcomes. Surg Endosc 27:2122–2130
19. Rosati CM, Boni L, Dionigi G, Cassinotti E, Giavarini L, David G, Rausei S, Rovera F, Dionigi R (2013) Single port versus standard laparoscopic right colectomies: results of a case control retrospective study on one hundred patients. Int J Surg 11(S1):S50–S53
20. Chew MH, Chang MH, Tan WS, Wong MTC, Tang CL (2013) Conventional laparoscopy versus single-incision laparoscopic right hemicolectomy: a case cohort comparison of short-term outcomes in 144 consecutive cases. Surg Endosc 27:471–477
21. Kanakala V, Borowski DW, Agarwal AK, Tabaqchali MA, Garg DK, Gill TS (2012) Comparative study of safety and outcomes of single-port access versus conventional laparoscopic colorectal surgery. Tech Coloproctol 16:423–428
22. Vetlhuis S, van den Boezem PB, Lips DJ, Prins HA, Cuesta MA, Sietses C (2012) Comparison of short-term surgical outcomes after single-incision laparoscopic versus multiport laparoscopic right colectomy: a two center, prospective case-controlled study of 100 patients. Dig Surg 29:477–483
23. Champagne BJ, Lee EC, Leblanc F, Stein SL, Delaney CP (2011) Single-incision vs straight laparoscopic segmental colectomy: a case-controlled study. Dis Colon Rectum 54:183–186
24. Chen WTL, Chang SC, Chiang HC, Lo WY, Jeng LB, Wu C, Ke TW (2011) Single-incision laparoscopic versus conventional laparoscopic right hemicolectomy: a comparison of short-term surgical results. Surg Endosc 25:1887–1892
25. Egi H, Hattori M, Hinoi T, Takakura Y, Kawaguchi Y, Shimomure M, Tokunaga M, Adachi T, Urushihara T, Itamoto T, Ohdan H (2012) Single-port laparoscopic colectomy versus conventional laparoscopic colectomy for colon cancer: a comparison of surgical results. W J Surg Oncol 10:61
26. Lai CW, Edwards TJ, Clements DM, Coleman MG (2011) Single port laparoscopic right colonic resection using a 'vessel first' approach. Color Dis 14:1138–1144
27. Adair J, Gromski MA, Lim RB, Nagle D (2010) Single-incision laparoscopic right colectomy: experience with 17 consecutive cases and comparison with multiport laparoscopic right colectomy. Dis Colon Rectum 53:1549–1554
28. McNally ME, Todd Moore B, Brown KM (2011) Single-incision laparoscopic colectomy for malignant disease. Surg Endosc 25:3559–3565
29. Hopping JR, Bardakcioglu O (2013) Single-port laparoscopic right colectomy: intermediate results. JLS 17:5–8
30. Keshava A, Young CJ, Mackenzie S (2010) Single-incision laparoscopic right colectomy. Br J Surg 97:1881–1883
31. Morales-Conde S, Barranco A, Socas M, Méndez C, Alarcon I, Canete J, Padillo FJ (2012) Improving the advantages of single port in right hemicolectomy: analysis of the results of pure transumbilical approach with intracorporeal anastomosis. Minim Invasive Surg 2012:4
32. van den Boezem PB, Sietses C (2011) Single-incision laparoscopic colorectal surgery, experience with 50 consecutive cases. J Gastrointest Surg 15:1989–1994
33. Baig MN, Moftah M, Deasy J, McNamara DA, Cahill RA (2012) Implementation and usefulness of single-access laparoscopic segmental and total colectomy. Color Dis 14:1267–1275
34. Waters JA, Guzman MJ, Fajardo AD, Selzer DJ, Wiebke EA, Robb BW, George VV (2010) Single-port laparoscopic right hemicolectomy: a safe alternative to conventional laparoscopy. Dis Colon Rectum 53:1467–1472

35. Vettoretto N, Cirocchi R, Randolph J, Parisi A, Farinella E, Romano G (2014) Single incision laparoscopic right colectomy: a systematic review and meta-analysis. Color Dis. doi:10.1111/codi.12526, 'Accepted Article'
36. Rijcken E, Mennigen R, Argyris I, Senninger N, Bruewer M (2012) Single-incision laparoscopic surgery for ileocolic resection in Crohn's disease. Dis Colon Rectum 55:140–146
37. Hopping JR, Bardakcioglu O (2013) Single-port laparoscopic right colectomy: the learning curve. JSJS 17:194–197
38. Senagore AJ, Delaney CP (2006) A critical analysis of laparoscopic colectomy at a single institution: lesson learned after 1000 cases. Am J Surg 191:377–380
39. Morino M (2012) Invited comment on Kanakala et al: comparative study of safety and outcomes of single-port access versus conventional laparoscopic colorectal surgery. Tech Coloproctol 16:429–430
40. Cirocchi R, Trastulli S, Farinelli E, Guarino S, Desiderio J, Boselli C, Parisi A, Noya G, Slim K (2013) Intracorporeal versus extracorporeal anastomosis during laparoscopic right hemicolectomy – systematic review and meta-analysis. Surg Oncol 22:1–13
41. http://clinicaltrials.gov/ct2/show/NCT01319890?term=right+colectomy+single&rank=1
42. Mynster T, Willie-Jørgensen P (2011) Single incision laparoscopic surgery: new 'toys for boys'? Color Dis 13:351

Single-Access Laparoscopic Left Hemicolectomy

9

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9.1 Introduction

The laparoscopic approach has been one of the major technical advances in surgery over the past 20 years. It is now the standard approach for many benign and malignant diseases. Advantages include lower morbidity, less postoperative pain, shorter hospital stay, long-term wound healing, and better cosmesis [1, 2]. Nevertheless, it still requires several ports which may be liable to complications, including bleeding, port-site hernia, risk of injury to internal organs, and pain. Some technical innovations have been developed to reduce parietal trauma and visible scars as well as minilaparoscopy, natural orifice transluminal endoscopic surgery (NOTES), and single-access laparoscopic surgery (SALS).

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_9,

In colorectal surgery, the standard laparoscopic approach requires several small port incisions and a medium-size laparotomy (normally a 5-cm Pfannenstiel) to remove the specimen, while SALS may reduce the parietal trauma, ensuring a scarless surgery as the wound is hidden within the umbilicus. Although SALS for colorectal resection was initially performed only for benign diseases, there is now an increasing adoption for malignancy, which raises questions concerning oncological adequacy. However, this approach is not yet used routinely for the treatment of benign and malignant colorectal disease, because clear advantages for the patient are still lacking.

We report our standardized technique as well as the case series in the use of a single-access laparoscopic approach for the treatment of left colon disease.

9.2 Surgical Technique (with Tips and Tricks)

9.2.1 Essential Operating Room Equipment

- Adjustable, remote-controlled electric split-leg table
- Monitor placed on the left side of the patient, with a hanging monitor above the patient's head
- One or two carbon dioxide insufflators maintaining a pneumoperitoneum of 12 mmHg
- Ultrasonic dissector device
- Set of readily available conventional open instruments
- A 5-mm 30° laparoscope, better if long and flexible endoscope as EndoEye Flex HD™ (Fig. 9.1)
- Long and straight atraumatic bowel graspers
- Scissors
- Bipolar diathermy forceps

Fig. 9.1 Surgical team position

- Monopolar diathermy hook
- Articulated linear stapler
- Circular stapler
- Suction irrigator
- Titanium clip applier, small and medium

9.2.2 Patient Position

The patient is placed in supine position with legs apart. The right arm is adducted, while the left one is opened. The surgeon is sitting at the right side of the patient, and the camera assistant is located to the right side of the first operator during the splenic flexure mobilization while to the left side during the other steps. The nurse stays between the legs of the patient.

It is mandatory to place nasogastric tube and bladder catheter.

The monitor is placed in front of the surgeon, at the level of the left thigh, so that the surgeon, working field and monitor represent almost subsequent points of the same axle.

We suggest to use the energy device having commands with pedals to obtain more hand freedom.

9.2.3 Step-by-Step Technique

All patients underwent single-access laparoscopic left hemicolectomy using the device "QuadPort Plus access system" (Advanced Surgical Concept, Tokyo, Japan). A 3–4-cm vertical incision was made in the umbilical fold. The umbilicus was suspended for the "QuadPort Plus access system" insertion, and the pneumoperitoneum was obtained with CO_2 gas (Fig. 9.2).

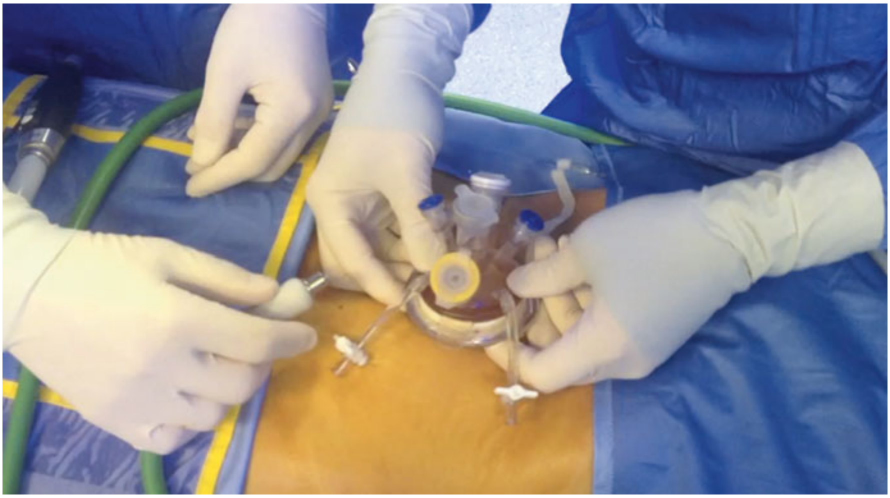

Fig. 9.2 QuadPort Plus access system device

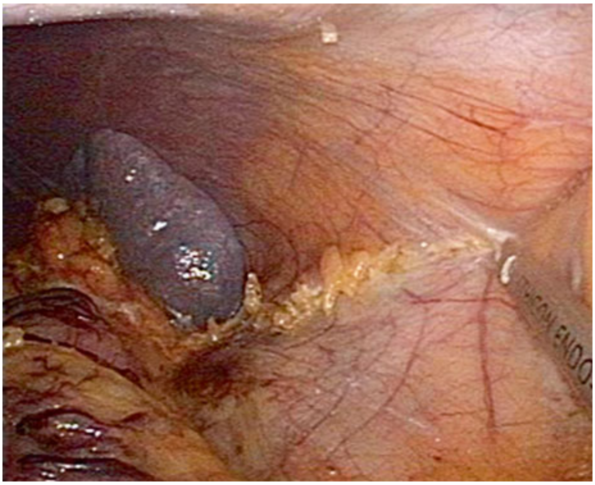

Fig. 9.3 Splenic flexure mobilization

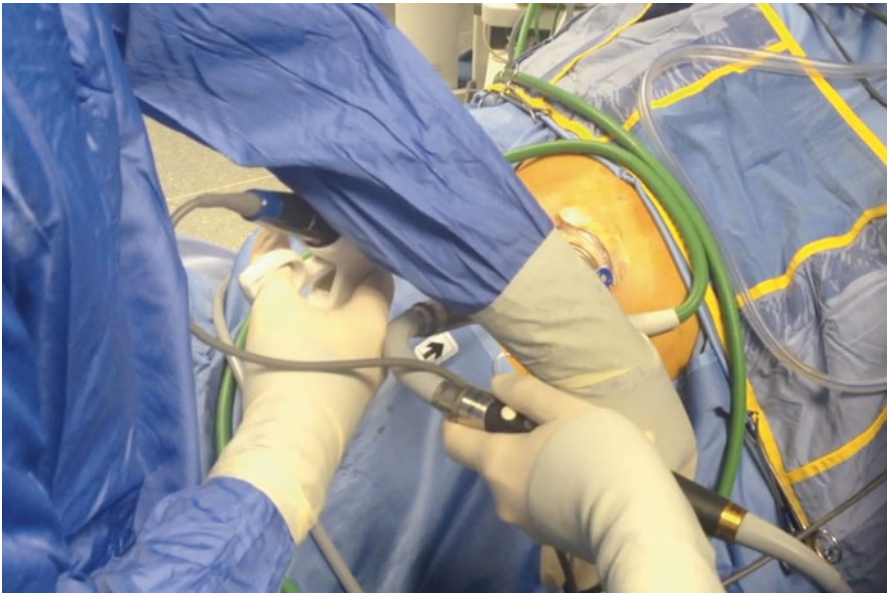

Fig. 9.4 Operator hands fight

In high reverse Trendelenburg position, the mobilization of the splenic flexure and descending and sigmoid colon was performed, and the Gerota fascia (Fig. 9.3) was detached from the Toldt fascia. The gonadal vessels and the left ureter were identified under the Gerota fascia. During this step, it is very important to find the best position between the straight graspers and the 5-mm camera. With some flexible optic, it is possible to avoid the internal instrument clashing as well as the operator hands fight (Fig. 9.4).

During a conventional laparoscopic colectomy, we used to dissect the plane between the Gerota and Toldt fascia pulling down the splenic flexure. During a

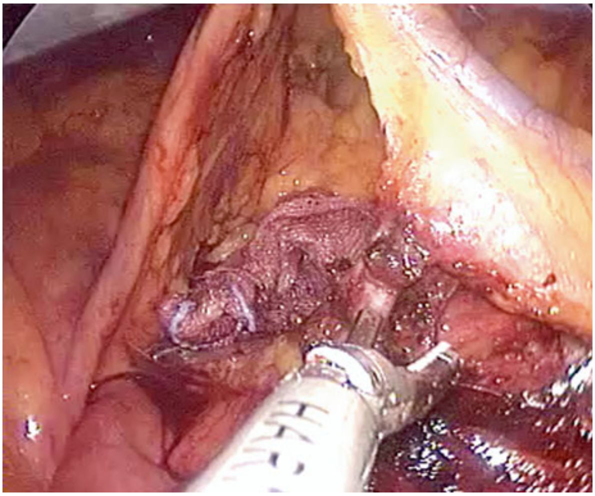

Fig. 9.5 Inferior mesenteric artery isolation

single-access procedure, instead, this movement is not very easy and effective. So we add to this an opposite movement of the right hand pushing down the Gerota fascia.

We suggest extending the dissection as much as possible down to the left parieto-colic ligament in such a way to make the next step easier.

In slight Trendelenburg position, the inferior mesenteric vein was isolated and transacted at the inferior margin of the pancreas after the incision of the Treitz muscle. The artery was isolated and transected about 2 cm over the aorta, after a complete mobilization of the sigmoid colon (Fig. 9.5).

In some cases of benign disease, we applied a standardized technique for the preservation of the inferior mesenteric artery (IMA) as reported by Valdoni et al. [3, 4].

The transection of the sigmoid-rectal junction was done in the same way as the conventional laparoscopic procedure. We suggest to use an articulated linear stapler with the handle rotated at the top.

The left colon resection was completed extracorporeally after the umbilical extraction (Fig. 9.6), and the head of the 33-mm circular stapler was inserted to the proximal colonic segment using a purse string of polypropylene. The T-T-stapled colorectal anastomosis was performed intracorporeally according to the Knight-Griffen technique and checked by hydro-pneumatic test.

The umbilical fascia was closed with continuous suture, and the skin was closed with Dermabond glue (Ethicon Inc, Cincinnati, OH, USA) (Fig. 9.7).

9.3 Our Experience

Our experience included 45 single-access left hemicolectomies with or without preservation of the IMA. All procedures were performed from October 2009 to August 2013.

The mean age was 63 years (range 37–84 years old); the mean BMI was 27.34 kg/m^2 (range 19.82–30.1 kg/m^2). Demographic and pathological features are summarized in Table 9.1.

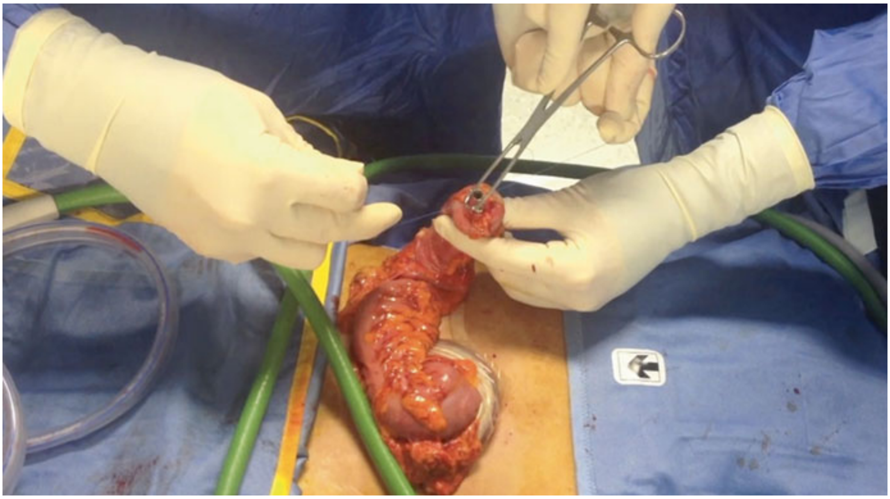

Fig. 9.6 Extracorporeal preparation of left colon

Fig. 9.7 Final result of skin incision

We added a trocar to complete the procedure only in three cases. No open conversion or mortality occurred (Table 9.2). We recorded four postoperative complications: in one case, it was necessary to reoperate with a conventional laparoscopic approach, due to ileal perforation.

The mean flatus canalization was 2 days (range 1–7 days). The mean discharge time was 5 days (range 4–37 days) (Table 9.3). At a mean 24-month follow-up, we found an umbilical incisional hernia.

Table 9.1 Demographic features

Demographic and pathological features	
Patient number	45
Male	18
Female	27
Age (mean/range) years	63/37–84
BMI (mean/range) kg/m^2	27.34/19.82–30
Diseases	
Left colon cancer	19
Diverticulitis	26
Previous abdominal surgery	
Appendectomy	16
Hysterectomy	4
Cholecystectomy	4
Annessectomy	1
Uterine myomectomy	1
Cesarean	4

Modified from Bracale et al. [5]

Table 9.2 Intraoperative data

Intraoperative data	
Surgical procedures	45
Left hemicolectomy	40
Left hemicolectomy with IMA preservation	5
Time (mean/range) min	143.7/97–215
Lymph nodes harvested (mean/range) n°	18/10–25
Final skin incision length (mean/range) cm	3.5/3–4.5
Blood transfusion	0
Ileostomy	0
Add trocar	3

Modified from Bracale et al. [5]

Table 9.3 Postoperative data

Postoperative data	
Complication	4
Pancreatitis	1
Ileal perforation	1
Hemorrhage	1
Bronchopneumonia	1
Discharge (mean/range) days	5/4–37
NSAID duration (mean/range) days	3/1–28
Flatus canalization (mean/range) days	2/1–7
Feces canalization (mean/range) days	3/1–7

Modified from Bracale et al. [5]

9.4 Discussion

Due to a rapidly increasing number of publications, there is now a need to assess the results of single-access laparoscopic left colectomy.

A meta-analysis on single-access laparoscopic colorectal surgery performed all over the world, conducted by Maggiori et al. [6] in 2012, records 251 cases of left hemicolectomy compared to conventional laparoscopic surgery. No differences were found in operation time and conversion rate compared with multiport laparoscopy. They concluded that the single-access laparoscopic colorectal resection is feasible only in experienced hands.

Only 1 comparative study conducted by Ramos-Valadez et al. [7], including 20 procedures, analyzed exclusively single-access left hemicolectomy. They concluded that this approach was safe and feasible with respect to the conventional laparoscopic approach without increased operative time, risk of complication, or prolonged hospitalization when performed by an experienced laparoscopic surgeon.

More generally, the single-access laparoscopic approach, along with the benefits brought by laparoscopy, could provide a reduction in complications related to abdominal trauma such as pain, faster discharge, and better cosmesis.

Most wrongly think that one of the drawbacks of single-access laparoscopic surgery when compared with multiport laparoscopic surgery is an increase of the need for equipment and a consequent increase in initial cost.

In our experience, however, as in other reports [5], it is feasible and safe to use conventional laparoscopic instruments.

During the first single-access procedures, we tried to use dedicated instruments, like articulating forceps. However, we suspended the use of articulating instruments because it is difficult to obtain adequate triangulation.

Similarly we tried to use a prototype camera with articulated tips. However, during the dissection maneuvers, the unavoidable instrument clash with the camera tips provided a very difficult view. In contrast, because of the possibility to avoid conflicts between the hands of both operators, we found very useful the camera with a long and articulated handle (Fig. 9.1).

The technical feasibility of single-access laparoscopic surgery might also be related to the umbilicus port. Several port designs are now available, but to date, there are no studies comparing different ports.

We start our experience with a previous version of the actual TriPort® system, recording many problems of gas leaks. The next version of the device surpassed this limit, but it does not allow enough freedom of movement of the instruments. The QuadPort® system, instead, has a wider-diameter cannula for the instruments, and it allows better freedom of movement. Moreover, the umbilical incision necessary for the QuadPort® system is more suitable for the specimen extraction than the TriPort® one.

As reported previously [5], surgeons experienced in single-access laparoscopic surgery describe a process of "reprogramming" where one learns how to operate with crossed instruments. More generally, according to Spana et al. [8], the surgeon needs to cross his or her hands, with the right-hand instrument crossing over to the left side and the left-hand instrument crossing over to the right side. The problem of clashing instruments could be overcome by the use of robotic surgery.

So these troubles could make the single-access approach a time-consuming procedure; more expensive, with a longer learning curve; less safe when attempted by inexperienced surgeons and less transferable than conventional multiport laparoscopic surgery.

Some surgeons have tried to resolve all these questions reporting their data through case-controlled studies or, in lesser extent, through small randomized controlled studies.

However, they collected data of many different surgical procedures (right and left colon resections, rectal anterior resection), making it difficult to analyze the results of each procedure.

It is important to appreciate that there are few data about the long-term results including abdominal function and late wound herniation. Maggiori et al. [6] stress that the major disadvantage is the need for an umbilical incision of 3–5 cm in length, which would expose the patient to a greater tendency toward developing incisional hernia than the conventional laparoscopy. This consideration is similar to that of Podolsky et al. [9].

Doubts could remain about the oncological adequacy of single-access laparoscopic colic resections. We reported a mean number of 18 harvested lymph nodes (range 10–25) similar to that reported by Huscher et al. [10] and by McNally et al. [11], respectively, which are 16 (±5) and 15 (range 3–32). From an oncological point of view, in all published cases, the resection margins always appear negative, and the number of harvested lymph nodes is equal to that reported in the literature relating to standard laparoscopic surgery. Moreover, at present, it is to be noted that there are no studies on long-term outcomes.

In conclusion, we believe that although the SALS is a feasible and safe technique when performed by experienced laparoscopic surgeons, to date, it cannot yet be considered as the procedure of choice for the treatment of left colon disease.

References

1. Bracale U, Guideline Committee of the Italian Society of Hospital Surgeons – ACOI and Italian Hi-Tech Surgical Club – IHTSC et al (2012) Laparoscopic gastrectomies for cancer: the ACOI-IHTSC national guidelines. Minim Invasive Ther Allied Technol 21:313–319
2. Corcione F, Bracale U, Barra L, Pirozzi F, Cuccurullo D, Andreoli F (2013) Standardization of laparoscopic left hemicolectomy: a single-center experience of 484 cases. Minerva Chir 68(5):513–521
3. Tocchi A et al (2001) Preservation of the inferior mesenteric artery in colorectal resection for complicated diverticular disease. Am J Surg 182(2):162–167
4. Valdoni P et al (1972) Preservation and peeling of the inferior mesenteric artery as a complication-preventing technique in the anterior resection of the rectum. Surg Italy 2:85–89
5. Bracale U et al (2013) Single access laparoscopic left hemicolectomy with or without inferior mesenteric artery preservation: our preliminary experience. Minerva Chir 68(3):315–320

6. Maggiori L et al (2012) Single-incision laparoscopy for colorectal resection: a systematic review and meta-analysis of more than a thousand procedures. Colorectal Dis 14(10):e643–e654
7. Ramos-Valadez DI et al (2012) Single-incision versus conventional laparoscopic sigmoid colectomy: a case-matched series. Surg Endosc 26(1):96–102
8. Spana G et al (2011) Is robotics the future of laparoendoscopic single-site surgery (LESS)? BJU Int 108(6 Pt 2):1018–1023
9. Podolsky ER et al (2010) Single port access (SPA) surgery–a 24-month experience. J Gastrointest Surg 14(5):759–767
10. Huscher CG et al (2012) Standard laparoscopic versus single-incision laparoscopic colectomy for cancer: early results of a randomized prospective study. Am J Surg 204(1):115–120
11. McNally ME et al (2012) Single-incision laparoscopic colectomy for malignant disease. Surg Endosc 25(11):3559–3565

Single Access Laparoscopic Rectal Anterior Resection

10

Léon Maggiori and Yves Panis

10.1 Introduction

Minimally invasive approach can be regarded as one of the major technical advances in surgery of the past 20 years. It has progressively become the standard approach for many benign and malignant diseases. As such, laparoscopy is now widely used for colorectal surgery. Compared to the open procedure, laparoscopic approach for colonic surgery provides various well-demonstrated benefits, including faster return of bowel function, less postoperative pain, shorter hospital stay, lower morbidity, and cosmetic advantage [1, 2]. Moreover, many studies have demonstrated the oncologic safety of laparoscopic colon cancer resection [3–5], as it is associated with similar results in terms of local control and survival, compared to standard open surgery. Furthermore, we have recently demonstrated, at a national level, that laparoscopy was independently associated with a lower postoperative mortality rate in colorectal cancer surgery [6].

On the other hand, the safety of the laparoscopy for rectal cancer management was initially questioned, mainly because of high rates of conversion and postoperative morbidity in subgroup analyses of the first randomized control trial (CLASICC trial) comparing open to laparoscopic approaches [5]. More recently, additional randomized control trials, specifically focusing on rectal cancer, demonstrated the safety of this minimally invasive approach even in this indication [2, 7, 8].

Interest in laparoscopy led to the development of more minimally invasive surgical approaches such as mini-laparoscopy, NOTES (natural orifice transluminal endoscopic surgery), and more recently single port laparoscopy. This latter technique is a technical refinement of the laparoscopic approach and consists of using a

No financial disclosure

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_10,

single multichannel port site, allowing the introduction of a camera and several instruments with only a 25–50-mm skin incision. In addition to the well-known advantages of laparoscopy, the main benefit of single port laparoscopy might be improved postoperative pain, postoperative recovery, and cosmetic results. To date, single port laparoscopy has been reported for various surgical procedures, and published experiences regarding more complex procedures such as colorectal surgery are rapidly growing. Although single port laparoscopy for colorectal resections was initially only performed for benign disease, there is now an increasing experience for colorectal malignancy.

As for laparoscopic approach in rectal cancer management, single port laparoscopy for rectal procedures raises some concern about feasibility and safety of this technically demanding surgery. In this chapter we will review the published literature about single port laparoscopy for low anterior resection and total mesorectal excision (TME), and we will describe our routine surgical technique for such cases.

10.2 Literature Review

10.2.1 Single Port Total Mesorectal Excision

Hamzaoglu et al. in January 2011 were the first to publish their experience with single port laparoscopic sphincter-saving excision for rectal cancer [9]. They reported a series of four patients. Two of them underwent a partial mesorectal excision with colorectal anastomosis and two underwent a total mesorectal excision. Results were encouraging as additional laparoscopic port or conversion to laparotomy was required, intraoperative blood loss ranged from 50 to 200 mL, operative time ranged from 240 to 480 min, and no postoperative complication was observed.

Since, several studies were published on the topic. After reporting our two initial cases of TME for cancer by single port approach [10], we reported the results of 25 single port laparoscopic colorectal procedures in a case-matched study, including three cases of single port laparoscopic proctectomy [11]. This study suggested the feasibility of this single port approach, as we did not observe any difference of postoperative mortality and morbidity, as compared to the standard multiport laparoscopic approach. In 2011, Bulut et al. reported ten consecutive cases of rectal cancer treated by single port laparoscopic approach with good postoperative results [12]. These results were recently updated, including 25 patients, with satisfactory results [13]. On the same way, Kim et al. [14] reported 73 colorectal cancer patients treated by single port surgery, including 32 rectal cancers. In this latter comparative study, although not randomized, postoperative morbidity was similar as compared to patients operated by multiport laparoscopy, but both return to normal bowel function and postoperative hospital stay was significantly shorter in single port patients. Additionally, two other recent papers reported 19 [15] and 8 [16] patients, respectively, with rectal cancer treated by single port, also with satisfactory postoperative results. Finally, very recently, Sourrouille et al. reported their results of 13 patients who underwent a sphincter-saving rectal resection for rectal cancer through a single port [17]. As compared to the outcomes of 32 patients who underwent the same procedure using a multiport laparoscopic approach, there was no difference in terms of oncologic quality of the resection, postoperative morbidity, or length of hospital stay. However, postoperative pain was reduced in the single port group.

In 2012, we performed a systematic review and meta-analysis on single port laparoscopic colorectal surgery [18], including all studies published as of December 2011. We identified 20 studies [9–12, 16, 19–33], all of retrospective design, which reported a total of 105 rectal procedures, including 55 low anterior resections (52 %), 4 abdominoperineal resections (4 %), and 46 total proctocolectomies (with or without ileal pouch–anal anastomosis) (44 %). Of these studies, only three were case-matched studies [11, 16, 30], all of them comparing single port to standard multiport approaches. One of the main conclusions of this meta-analysis was the questioned technical feasibility of single port laparoscopic rectal surgery, as only 67 % were successfully completed through an SIL approach. Indeed, conversion to multiport laparoscopy was needed in 32 cases (30 %) and conversion to laparotomy was needed in three cases (3 %).

On the other hand, this meta-analysis demonstrated that postoperative outcomes of single port laparoscopic rectal surgery were acceptable, as compared to the standard multiport approach. Pooled postoperative 30-day mortality rate was 0.2 % and meta-analysis of the comparative studies showed no difference of postoperative morbidity rates between single port laparoscopy and multiport laparoscopic surgery (odds ratio, 0.84 [0.61;1.15]; $p=0.27$. Furthermore, we suggested that single port approach might be associated with some benefits as compared to the multiport approach as the single port approach was associated with a significantly shorter total skin incision (weighted mean difference: −0.52 [−0.79;−0.25]; $p<0.001$) and a significantly shorter length of postoperative hospital stay (weighted mean difference: −0.75 [−1.30;−0.20]; $p=0.008$), as compared to the multiport approach. Finally, this meta-analysis stressed out the point that single port laparoscopic surgery might be acceptable regarding the oncologic results obtained. Indeed, all reported surgical margins were negative (R0) and all studies reported a mean number of harvested lymph nodes of 12 or more. However, to date, long-term follow-up of single port TME for rectal cancer was not reported in any study and both overall and disease-free survivals remain unknown.

Similarly, two additional literature reviews have recently been published on the same topic [34, 35]. The first one [34] suggested that single port laparoscopic approach was feasible and safe when performed by surgeons highly experienced in laparoscopy. The authors concluded that, despite technical difficulties, single port laparoscopy might be associated with potential benefits (i.e., size of the incision, hospital stay, operative time) as compared to its multiport counterpart, but those remain yet to be proven objectively. The second review, focusing only on colon cancer [35], suggested that single port laparoscopic approach may be associated with a lower postoperative morbidity rate, as compared to the results of large randomized control trials of multiport laparoscopic approach.

More recently, two small-sampled randomized studies have been recently reported on single port laparoscopic colonic surgery [36, 37], although they did not include rectal procedures. The first one, authored by Poon et al., included 50 patients and demonstrated significantly shorter hospital stay and lower postoperative pain in patients operated by single port [37]. The second study in 32 patients demonstrated that operative results were similar in both single port and standard laparoscopy groups [36].

10.2.2 Transanal–Transabdominal Total Mesorectal Excision

Several authors published their experience with transanal–transabdominal TME. Different surgical techniques were reported, mostly because of variations of the percentage of the TME dissection performed through the transanal approach. Indeed this transanal dissection may vary from an isolated intersphincteric dissection, as we previously described [10], to a complete TME [38], associated with a single port transabdominal approach.

The complete transanal TME derives from the natural orifice transluminal endoscopic surgery (NOTES) technique, initially described in bovine [39] and human cadaver [40] and firstly described in human using a multiport laparoscopic assistance by Sylla et al. [41]. In 2011, Tuech et al. reported the first case of complete transanal TME with a single port laparoscopic assistance in a 45-year-old for a low rectal adenocarcinoma [42]. In September 2012, Dumont et al. reported the first series of four patients with rectal cancer treated with this approach [38]. Results were encouraging, as additional laparoscopic port or conversion to laparotomy was not required, mean intraoperative blood loss was 175 mL, and all surgical margins were classified R0. After a mean follow-up of 3 months, Wexner scores indicated no severe incontinence in any patient. The authors concluded that this technique was feasible despite the limited working space in the pelvic area. Furthermore, they hypothesized that this transanal approach for TME may be superior to the transabdominal TME for large pelvic tumors, minimizing the risk of perforation and presacral bleeding. Similar results were observed regarding an updated population of seven patients in 2013 [17]. Choi et al. also published their results of 22 patients operated on with this technique [43]. No intraoperative complication was observed and no additional port or conversion to open surgery was required. Furthermore, the median number of harvested lymph nodes was 22 and the median distal margin from the tumor was 2 cm, suggesting a satisfactory oncologic resection. However, to date, no study compared the results of the transanal TME to those obtained after transabdominal approach. In our department, we consider that a total transanal TME presents two major drawbacks: firstly, the major anal sphincter required might jeopardize the postoperative anal function; secondly, a hand-sewn coloanal anastomosis is the rule after this technique, irrespective of the tumor distance from the anal verge and therefore even in mid-rectal cancer where stapled anastomosis is feasible. For these reasons, when a hand-sewn anastomosis is indicated (i.e., low rectal cancer), we always begin the TME dissection from a perineal approach but only up to approximately 5–6 cm from the dentate line. Subsequently, we routinely performed a standard abdominal laparoscopic approach.

In their study, Dumont et al. advocate to reserve this technique to patients requiring an intersphincteric dissection for oncologic reasons, i.e., tumors located at 2 cm or less of the anal verge [38].

10.3 Surgical Technique

We routinely perform transabdominal approach with stapled low colorectal anastomosis for single port laparoscopic rectal cancer management, reserving the transanal–transabdominal with hand-sewn anastomosis for patients requiring either a standard coloanal anastomosis on the dentate line (rectal tumor located at less than 3 or 4 cm from the dentate line, for which stapled anastomosis will be very difficult by abdominal approach) or for intersphincteric dissection for lesions located at less than 1 cm from the dentate line.

10.3.1 Transabdominal Approach and Stapled Low Colorectal Anastomosis

The surgeon and a first assistant are positioned on the right of the patient. A second assistant is placed on the left. As we always perform a diverting lateral ileostomy in rectal cancer cases, the single port device is placed through a 25-mm skin incision in the right lower quadrant, at the precise stoma location. The procedure is performed using a 5-mm laparoscope with a 0° tip, a 5-mm Ultracision Harmonic scalpel (Ethicon Endo-Surgery, Spreitenbach, Switzerland), a 10-mm endoscopic linear stapler, and conventional straight 5-mm laparoscopic graspers. We routinely use the Octoport for single port (Landanger).

Single port TME is performed using the same technique as for standard laparoscopic TME with a medial-to-lateral approach. It begins by a medial approach (after placing the patient in 30° Trendelenburg with 20° right lateral tilt position, using one assistant grasper and the gravitational force) with vein division, dissection of the pancreas from below, mobilization of the transverse and left mesocolon, and, after a clear identification of the left ureter, division of the inferior mesenteric artery. Then, splenic flexure mobilization and left colonic mobilization are finished laterally. During the step of splenic flexure mobilization, and because frequently the single port is too far for the splenic flexure, we add a 5-mm trocar on the left lower quadrant which help for this step and which will be used for the suction drain left in place in the pelvis at the end of the operation. TME is then performed down to the pelvic floor. The rectum is distally transected using an endoscopic linear stapler using one or two cartridges.

The specimen is extracted through the single port incision in the right lower quadrant. The colon is proximally transected and prepared, allowing the insertion of a circular stapler anvil. The colon is returned in the abdominal cavity, the single port device is reinserted, and the pneumoperitoneum is reestablished. A low side-to-end colorectal anastomosis is then mechanically performed using a transanally inserted circular stapler. A pelvic suction drain is placed and the last ileal loop is exteriorized through the site of insertion of the single port laparoscopic device.

10.3.2 Transabdominal–Transanal Approach with Hand-Sewn Coloanal Anastomosis

For transabdominal–transanal approach, we routinely use a primary transanal approach. With the patient in lithotomy position, a Lone Star Retractor System (Lone Star Medical Products, Inc., Stafford, TX) is introduced for surgical exposure. The anal canal is divided circumferentially according to the level of the tumor (i.e., at least 10 mm distal to the lower edge of the tumor). An intersphincteric dissection is then performed up to 5 cm above the dentate line. During this dissection, the anorectal lumen is closed as soon as possible with a running suture, in order to avoid any subsequent tumor spillage and for traction and exposure during the dissection. The transabdominal approach is then performed using the same technique as depicted above, except that the specimen is extracted through the anal canal and a hand-sewn side-to-end coloanal anastomosis is performed.

Conclusion

Published studies regarding single port laparoscopic TME are scarce and no randomized control trial is available to date. However, review of the literature suggests that single port laparoscopic TME is technically demanding but feasible and safe. Furthermore, it may be associated with improved postoperative outcomes as compared to the standard multiport approach. Long-term results of this procedure and well-designed prospective studies are eagerly awaited for, as they will allow complete demonstration of the outcomes associated with this novel minimally invasive approach.

References

1. Clinical Outcomes of Surgical Therapy Study Group (2004) A comparison of laparoscopically assisted and open colectomy for colon cancer. N Engl J Med 350:2050–2059
2. Lujan J, Valero G, Hernandez Q, Sanchez A, Frutos MD, Parrilla P (2009) Randomized clinical trial comparing laparoscopic and open surgery in patients with rectal cancer. Br J Surg 96:982–989
3. Fleshman J, Sargent DJ, Green E, Anvari M, Stryker SJ, Beart RW Jr et al (2007) Laparoscopic colectomy for cancer is not inferior to open surgery based on 5-year data from the COST study group trial. Ann Surg 246:655–664
4. Veldkamp R, Kuhry E, Hop WC, Jeekel J, Kazemier G, Bonjer HJ et al (2005) Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. Lancet Oncol 6:477–484
5. Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM et al (2005) Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet 365:1718–1726
6. Panis Y, Maggiori L, Caranhac G, Bretagnol F, Vicaut E (2011) Mortality after colorectal cancer surgery: a French survey of more than 84,000 patients. Ann Surg 254:738–744
7. Kang SB, Park JW, Jeong SY, Nam BH, Choi HS, Kim DW et al (2010) Open versus laparoscopic surgery for mid or low rectal cancer after neoadjuvant chemoradiotherapy (COREAN

trial): short-term outcomes of an open-label randomised controlled trial. Lancet Oncol 11:637–645
8. van der Pas MH, Haglind E, Cuesta MA, Furst A, Lacy AM, Hop WC et al (2013) Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomised, phase 3 trial. Lancet Oncol 14:210–218
9. Hamzaoglu I, Karahasanoglu T, Baca B, Karatas A, Aytac E, Kahya AS (2011) Single-port laparoscopic sphincter-saving mesorectal excision for rectal cancer: report of the first 4 human cases. Arch Surg 146:75–81
10. Gaujoux S, Bretagnol F, Au J, Ferron M, Panis Y (2011) Single port access proctectomy with total mesorectal excision and intersphincteric resection with a primary transanal approach. Colorectal Dis 13:e305–e307
11. Gaujoux S, Maggiori L, Bretagnol F, Ferron M, Panis Y (2012) Safety, feasibility, and short-term outcomes of single port access colorectal surgery: a single institutional case-matched study. J Gastrointest Surg 16:629–634
12. Bulut O, Nielsen CB, Jespersen N (2011) Single-port access laparoscopic surgery for rectal cancer: initial experience with 10 cases. Dis Colon Rectum 54:803–809
13. Bulut O, Aslak KK, Rosenstock S (2014) Technique and short-term outcomes of single-port surgery for rectal cancer: a feasibility study of 25 patients. Scand J Surg 103(1):26–33
14. Kim SJ, Ryu GO, Choi BJ, Kim JG, Lee KJ, Lee SC et al (2011) The short-term outcomes of conventional and single-port laparoscopic surgery for colorectal cancer. Ann Surg 254:933–940
15. Vestweber B, Galetin T, Lammerting K, Paul C, Giehl J, Straub E et al (2013) Single-incision laparoscopic surgery: outcomes from 224 colonic resections performed at a single center using SILS. Surg Endosc 27:434–442
16. Champagne BJ, Papaconstantinou HT, Parmar SS, Nagle DA, Young-Fadok TM, Lee EC et al (2012) Single-incision versus standard multiport laparoscopic colectomy: a multicenter, case-controlled comparison. Ann Surg 255:66–69
17. Sourrouille I, Dumont F, Goere D, Honore C, Elias D (2013) Resection of rectal cancer via an abdominal single-port access: short-term results and comparison with standard laparoscopy. Dis Colon Rectum 56:1203–1210
18. Maggiori L, Gaujoux S, Tribillon E, Bretagnol F, Panis Y (2012) Single-incision laparoscopy for colorectal resection: a systematic review and meta-analysis of more than a thousand procedures. Colorectal Dis 14:e643–e654
19. Gash KJ, Goede AC, Chambers W, Greenslade GL, Dixon AR (2011) Laparoendoscopic single-site surgery is feasible in complex colorectal resections and could enable day case colectomy. Surg Endosc 25:835–840
20. Geisler DP, Kirat HT, Remzi FH (2011) Single-port laparoscopic total proctocolectomy with ileal pouch-anal anastomosis: initial operative experience. Surg Endosc 25:2175–2178
21. Chambers WM, Bicsak M, Lamparelli M, Dixon AR (2011) Single-incision laparoscopic surgery (SILS) in complex colorectal surgery: a technique offering potential and not just cosmesis. Colorectal Dis 13:393–398
22. Chew MH, Wong MT, Lim BY, Ng KH, Eu KW (2011) Evaluation of current devices in single-incision laparoscopic colorectal surgery: a preliminary experience in 32 consecutive cases. World J Surg 35:873–880
23. Leblanc F, Makhija R, Champagne BJ, Delaney CP (2011) Single incision laparoscopic total colectomy and proctocolectomy for benign disease: initial experience. Colorectal Dis 13:1290–1293
24. Podolsky ER, Curcillo PG 2nd (2010) Single port access (SPA) surgery–a 24-month experience. J Gastrointest Surg 14:759–767
25. Ross H, Steele S, Whiteford M, Lee S, Albert M, Mutch M et al (2011) Early multi-institution experience with single-incision laparoscopic colectomy. Dis Colon Rectum 54:187–192
26. Gash KJ, Goede AC, Kaldowski B, Vestweber B, Dixon AR (2011) Single incision laparoscopic (SILS) restorative proctocolectomy with ileal pouch-anal anastomosis. Surg Endosc 25:3877–3880

27. van den Boezem PB, Sietses C (2011) Single-incision laparoscopic colorectal surgery, experience with 50 consecutive cases. J Gastrointest Surg 15:1989–1994
28. Uematsu D, Akiyama G, Narita M, Magishi A (2011) Single-access laparoscopic low anterior resection with vertical suspension of the rectum. Dis Colon Rectum 54:632–637
29. Lauritsen ML, Bulut O (2012) Single-port access laparoscopic abdominoperineal resection through the colostomy site: a case report. Tech Coloproctol 16:175–177
30. Lee SW, Milsom JW, Nash GM (2011) Single-incision versus multiport laparoscopic right and hand-assisted left colectomy: a case-matched comparison. Dis Colon Rectum 54:1355–1361
31. Geisler D, Garrett T (2011) Single incision laparoscopic colorectal surgery: a single surgeon experience of 102 consecutive cases. Tech Coloproctol 15:397–401
32. Bulut O, Nielsen CB (2010) Single-incision laparoscopic low anterior resection for rectal cancer. Int J Colorectal Dis 25:1261–1263
33. Geisler DP, Condon ET, Remzi FH (2010) Single incision laparoscopic total proctocolectomy with ileopouch anal anastomosis. Colorectal Dis 12:941–943
34. Makino T, Milsom JW, Lee SW (2012) Feasibility and safety of single-incision laparoscopic colectomy: a systematic review. Ann Surg 255:667–676
35. Fung AK, Aly EH (2012) Systematic review of single-incision laparoscopic colonic surgery. Br J Surg 99:1353–1364
36. Huscher CG, Mingoli A, Sgarzini G, Mereu A, Binda B, Brachini G et al (2012) Standard laparoscopic versus single-incision laparoscopic colectomy for cancer: early results of a randomized prospective study. Am J Surg 204:115–120
37. Poon JT, Cheung CW, Fan JK, Lo OS, Law WL (2012) Single-incision versus conventional laparoscopic colectomy for colonic neoplasm: a randomized, controlled trial. Surg Endosc 26:2729–2734
38. Dumont F, Goere D, Honore C, Elias D (2012) Transanal endoscopic total mesorectal excision combined with single-port laparoscopy. Dis Colon Rectum 55:996–1001
39. Bhattacharjee HK, Buess GF, Becerra Garcia FC, Storz P, Sharma M, Susanu S et al (2011) A novel single-port technique for transanal rectosigmoid resection and colorectal anastomosis on an ex vivo experimental model. Surg Endosc 25:1844–1857
40. Whiteford MH, Denk PM, Swanstrom LL (2007) Feasibility of radical sigmoid colectomy performed as natural orifice transluminal endoscopic surgery (NOTES) using transanal endoscopic microsurgery. Surg Endosc 21:1870–1874
41. Sylla P, Rattner DW, Delgado S, Lacy AM (2010) NOTES transanal rectal cancer resection using transanal endoscopic microsurgery and laparoscopic assistance. Surg Endosc 24:1205–1210
42. Tuech JJ, Bridoux V, Kianifard B, Schwarz L, Tsilividis B, Huet E et al (2011) Natural orifice total mesorectal excision using transanal port and laparoscopic assistance. Eur J Surg Oncol 37:334–335
43. Choi BJ, Lee SC, Kang WK (2013) Single-port laparoscopic total mesorectal excision with transanal resection (transabdominal transanal resection) for low rectal cancer: initial experience with 22 cases. Int J Surg 11(33):858–863

Single-Access Laparoscopic Approach for Pancreatic Surgery

11

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11.1 Introduction

Laparoscopic surgery is a technology-dependent medical revolution, which is directly performed by skillful and well-trained surgeons. Therefore, this endless challenge made this technique worldwide accepted for many surgical procedures.

Since laparoscopic pancreas surgery was first introduced in 1994 [1, 2], technique continues to gain acceptance as an option for the surgical management of the disease. The recent improvements in medical technologies, including staplers, coagulation devices, and minimal invasive surgical instruments, caused an acceleration in the frequency of laparoscopic distal pancreatectomies; moreover, the number of centers performing laparoscopic distal pancreas resection with good clinical results including less morbidity and shorter hospital stay is dramatically increasing worldwide [2–6].

Recently, for more cosmetic requests of the patients, to further minimize the surgical trauma and scar, surgeons develop a new minimally invasive technique called single-access laparoscopic surgery (SALS). This approach has been successfully applied in many fields of abdominal surgery since its first use for laparoscopic cholecystectomy in 1997 by Navarra et al. [7].

The aim of this technique was to decrease the number of trocars from 4 to 5 to single and if possible preferably through the umbilicus. Among these techniques, there are also advanced procedures like hepatectomy, splenectomy, colectomy, and gastric resections [8–11]. Till now, comparative reports between standard multi-trocar laparoscopy and single-access technique did not reveal any significant advantages except than cosmetics [5, 12].

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_11, © Springer International Publishing Switzerland 2014

In our center, we started this technique with appendectomies and cholecystectomies (Table 11.1). After having sufficient experience regarding the steep-learning curve in this technique, we performed the first single-incision splenectomy, and right after this, we performed the first single-incision laparoscopic distal pancreatectomy [9, 13].

In this chapter, we will discuss the technical details of single-access laparoscopic pancreas resection together with its advantages and disadvantages.

11.1.1 Our Experience

Our first case was a female patient who underwent surgery with the diagnosis of renal cancer. During her follow-up period, she referred us with multifocal pancreatic metastasis of a renal cancer. After this first case, we continued to perform single-access laparoscopic pancreas resection for different pathologies including insulinoma, adenocarcinoma, mucinous cyst adenoma, and nonfunctional neuroendocrine tumor.

After performing ten cases of SALS distal pancreatectomies, we achieved to preserve spleen only in one of the cases. This patient had an insulinoma located at pancreatic tail. In this case, after defining the localization of the lesion with laparoscopic ultrasonography, we preserved short gastric vessels. Although we sacrificed the splenic artery, we protected the spleen successfully in the end. In three cases (30 %), we had low-flow pancreatic fistula which ceased spontaneously during the follow-up period. In one case, we had umbilical trocar site hernia. We had no conversion to multi-trocar laparoscopy or open surgery, and no mortality occurred. The main problem was the duration of the surgical procedure which was as expected longer than standard laparoscopic distal pancreatectomies.

In all our cases, we routinely used suction drains which were located in the pancreatectomy bed. Before the removal of drains, we always analyzed the drain fluid for amylase level. If this level was three times higher than normal serum amylase levels, we did not remove the drain and accepted as pancreatic fistula.

One of the main challenging steps of the procedure was caused by the sword fight of the laparoscopic instruments both inside and outside of the abdomen. In order to prevent or minimize this challenge, the use of roticulated instruments is mandatory for this technique. Today, we have even angulated energy devices that are very useful for hemostasis in advanced laparoscopic procedures. The smoke inside the abdomen and air leak are the other minor technical problems during advanced single-access laparoscopic procedures. Using standard laparoscopic trocars can be a solution for the easy evacuation of intra-abdominal fog. Air leak is usually caused by deformation of the special single-access trocars toward the end of the procedure due to overextension of the laparoscopic tools. You can deal with this problem by having an extra single-access trocar for change where needed. The details of our SALS distal pancreatectomy experience are summarized in Table 11.2.

Table 11.1 Operative data of our SALS series

Type of operation (n = 151) [14]	Indication for operation	Mean operative time (min)	Intraoperative blood loss (cc)	Conversion (Y/N)	Mean length of hospital stay (day)	Early postoperative complication	Late postoperative complication
Cholecystectomy (n = 71) [15, 16]	Gallstones (n = 69) Gallbladder polyp (n = 2)	50 (35–90)	0	N	1.1	Cystic stump leak (n = 1)	Port site hernia (n = 1)
Splenectomy (n = 22) [9]	Immune thrombocytopenic purpura (n = 21) Wandering spleen syndrome (n = 1)	65 (40–180)	0–300	Y (N = 1)	2.2	Pancreatic fistula (n = 1) Arterial hemorrhage (n = 1)	No
Hernia repair (n = 17) [17]	Inguinal hernia (n = 12) Umbilical hernia (n = 3) Incisional hernia (n = 2)	40 (35–65) 40 (32–75) 65 (45–90)	0	N	1	No	No
Appendectomy (n = 11)	Acute appendicitis (n = 11)	35 (29–65)	0	N	1	No	Port site hernia (n = 1)
Partial colon resection (n = 8)	Sigmoid colon tumor (n = 7) Rectosigmoid tumor (n = 1)	90 (70–130)	0	N	6.5	No	No
Distal pancreatectomy and splenectomy (n = 10) [13]	Insulinoma (n = 3) Adenocarcinoma (n = 1) Neuroendocrine tumor (n = 4) Pancreas pseudocyst (n = 1) Renal cell cancer metastasis (n = 1)	181 (120–330)	30–500	N	8.1	Pancreatic fistula (n = 1) Gastric atony (n = 1) Pancreatic fistula (n = 1) Pancreatic fistula (n = 1)	Port site hernia (n = 1)

(continued)

Table 11.1 (continued)

Type of operation ($n = 151$) [14]	Indication for operation	Mean operative time (min)	Intraoperative blood loss (cc)	Conversion (Y/N)	Mean length of hospital stay (day)	Early postoperative complication	Late postoperative complication
Subtotal gastrectomy ($n = 4$)	Gastric cancer ($n = 3$) Gastric stromal tumor ($n = 1$)	245 (180–310)	50–310	N	5	Pancreatic fistula ($n = 1$)	Port site hernia ($n = 1$)
Partial liver resection ($n = 3$) [18]	Hemangioma ($n = 2$) Hepatic adenoma ($n = 1$)	120 (110–145)	50–200	N	3	No	No
Adrenalectomy ($n = 3$)	Conn syndrome ($n = 1$) Adrenal carcinoma ($n = 1$) Metastatic adrenal carcinoma ($n = 1$)	60 (50–75)	30–50	N	3.3	Pancreatic fistula ($n = 1$)	No
Nissen fundoplication ($n = 2$) [19]	Hiatal hernia ($n = 2$)	105 (100–120)	0	N	1	No	No

Table 11.2 The details of our SALS distal pancreatectomy case series

Cases	Age/sex	BMI	Diagnosis	Operative time (min)	Intraoperative blood loss	Conversion (Y/N)	Length of hospital stay	Complication
1	59/F	31.1	Metastatic renal cell cancer	330	100	N	7	Pancreatic fistula
2	52/M	30.3	Insulinoma	210	125	N	5	–
3	48/F	27.8	Neuroendocrine tumor	205	140	N	5	Port site hernia
4	39/F	26.3	Neuroendocrine tumor	180	210	N	7	Pancreatic fistula
5	33/F	41.2	Pancreas pseudocyst	165	50	N	7	–
6	29/F	24.7	Neuroendocrine tumor	135	500	N	20	Gastric atony
7	57/M	27.1	Adenocarcinoma	150	115	N	12	Pancreatic fistula
8[a]	27/M	29.2	Insulinoma	160	90	N	7	–
9	47/F	28.4	Insulinoma	120	65	N	6	–
10	40/M	25.5	Neuroendocrine tumor	145	30	N	5	–

[a]Spleen preserving achieved in this patient

11.2 Surgical Technique

Step 1: Patient setup and trocar placement
The patient was placed in a supine and reverse Trendelenburg position (30°) with open legs. The surgeon stood between the legs; the first assistant was on the left side of the patient with the monitor placed on the patient's cranial side. With the patient under general anesthesia, a completely transumbilical 2-cm skin incision was performed. A special SALS port having four working channels was placed through the umbilical incision. Pneumoperitoneum was applied through this port. After the maintenance of 12 mmHg CO_2 pneumoperitoneum, the three 5-mm cannulas were inserted inside through this special SALS port (Fig. 11.1). We used a rigid 30° 5-mm laparoscope and two standard rigid but articulating instruments.

As an alternative route, in two cases, we used standard laparoscopic trocars through a 2-cm transumbilical incision. Initially, we started with three 5-mm trocars that were introduced into the abdomen from different places of 1 cm apart from each other. In this technique, the location of trocars was formed a triangulation (Fig. 11.2).

Step 2: Pneumoperitoneum and entry to lesser sac
We used 5-mm laparoscopic instruments for all SALS procedures. Once the laparoscope, grasper, and dissector were placed, the overall procedures were similar to the procedures performed in a five-port laparoscopic pancreatectomy. The most difficult part of this technique was that the working instruments were crossing each other and roticulated. The 5-mm telescope was introduced under both of the working instruments and sometimes over them, changing according to the surgical step of the procedure. After less invasive entry into the abdomen, there was not any difference from the multi-trocar laparoscopic pancreatectomy technique. During all these steps, at least one of the pieces of equipment, roticulated grasper and dissector, was used. Following a diagnostic laparoscopy, the lesser sac was entered following the division of the gastrocolic ligament using the advanced LigaSure probe (Valleylab, Boulder, CO, USA). The whole pancreatic body and tail were then exposed (Fig. 11.3).

Step 3: Retraction of stomach
Before starting pancreatic dissection, we placed a loop encircling the stomach corpus by crossing the lesser curvature and greater curvature for preoperative continuous retraction. We prepared the loop by using polypropylene suture covered with a plastic tube of intravenous serum set to prevent a possible stomach injury. Two tips of this suture were taken out of the abdominal cavity with a suture passer placed under the xiphoid process. During the entire procedure, stomach retraction was provided with this tensed-loop Prolene securing the stomach (Fig. 11.4).

Step 4: Determination of the lesion site
Usually, superficial lesions are easily defined. However, as in standard laparoscopic pancreatic surgery, intraoperative laparoscopic ultrasonography is a mandatory tool, which helps not only to define the localization of the lesion but also to detect a healthy transection site on pancreatic tissue. In order to introduce laparoscopic ultrasonography probe, one of the 5-mm trocars should be changed with a 12-mm trocar (Fig. 11.5).

Fig. 11.1 Special SALS port with roticulated instruments

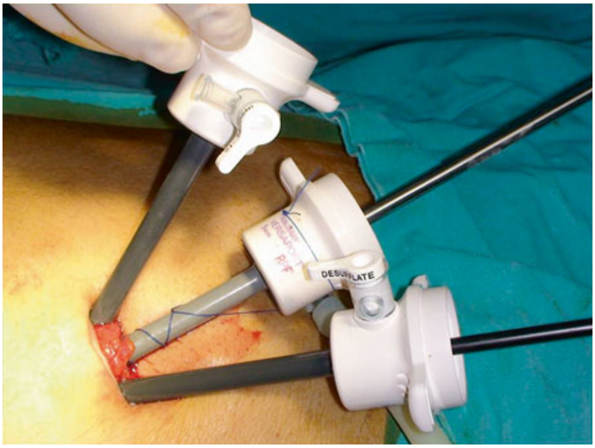

Fig. 11.2 Standard trocars located through the umbilicus

Fig. 11.3 Intraoperative photo showing the widening of the gastrocolic window

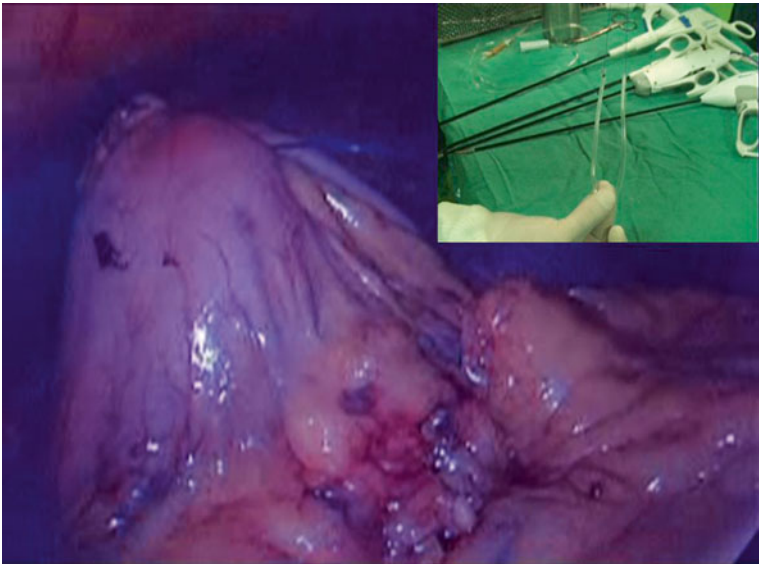

Fig. 11.4 Photo showing gastric retraction with loop technique and loop alone

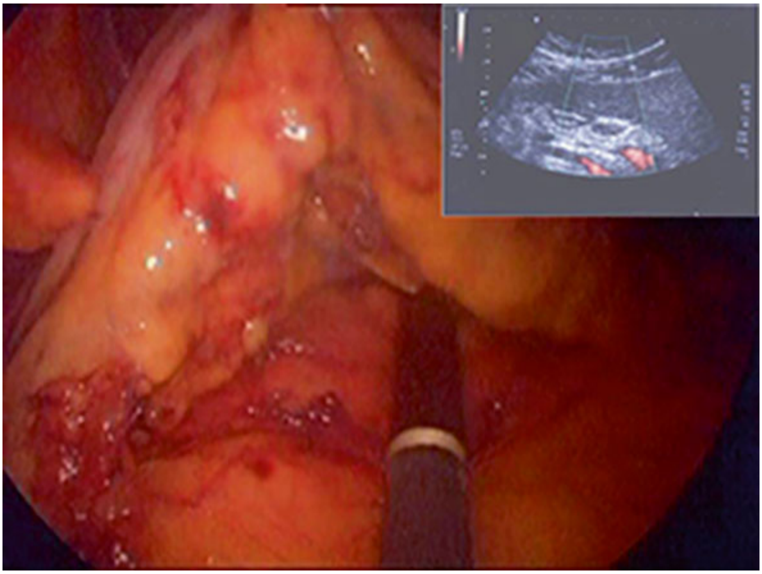

Fig. 11.5 Intraoperative photo showing the transection of the pancreatic neck with endoscopic stapler

Step 5: Transection and dissection of the pancreatic tail
One of the 5-mm trocars was replaced by a 15-mm trocar to be able to introduce a linear stapler. The pancreas was then transected by using two 45-mm Endo-GIA staplers or one 60-mm Endo-GIA stapler (US Surgical Corp., Norwalk, CT, USA). We prefer thick tissue cartridge (4.5 mm) as stapler. The "medial-to-lateral"

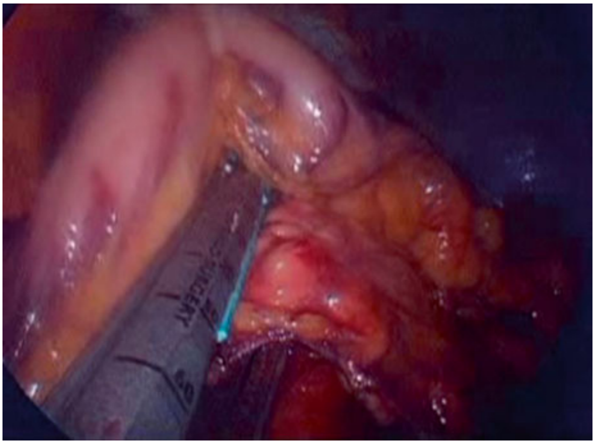

Fig. 11.6 Photo showing en bloc resected pancreas specimen

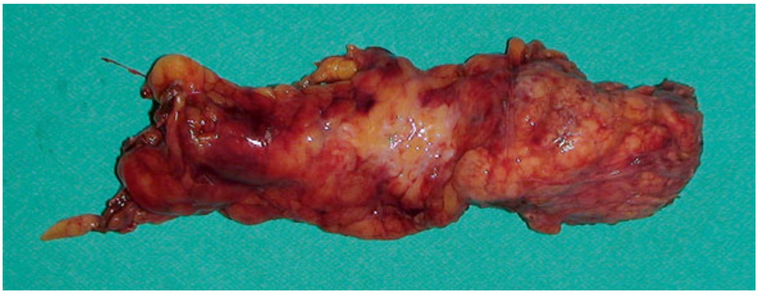

Fig. 11.7 Photo showing the postoperative appearance of the umbilical incision

technique was the chosen method for tumors located at the body and proximal tail of the pancreas. The peritoneal lining along the inferior edge of the pancreas was dissected at the point where transection of the pancreas would be carried. Then, an adequate window was created; a roticulated grasper was passed around the body of the gland. The splenic vessels were identified and ligated with LigaSure at this level (Fig. 11.6) and dissection of the pancreas from the pancreatic bed was started. Dissection was carried out in a medial-to-lateral fashion from the tail toward the hilum of the spleen. Retroperitoneal dissection can take time because of dense fibrosis of the region caused by a previous surgical procedure. In this manner, the distal portion of the pancreas containing the tumor can be removed together with splenic vessels and the spleen itself with its retroperitoneal attachments, and thus freed. Once the distal pancreas was mobilized, the stapled closure of the proximal pancreatic stump was reinforced with fibrin glue. The splenic part of the specimen was retrieved using the Endo-Catch 15 (US Surgical Corp, Norwalk, CT, USA) by morcellation, and then, the pancreatic part of the specimen was delivered through the umbilical port site as an intact piece (Fig. 11.7). A closed system suction drain was placed in the lesser sac. The umbilical site was sutured with no. 0 polypropylene suture. The skin closure can be done with either stapler or monofilament absorbable sutures (Fig. 11.8).

Fig. 11.8

11.3 Discussion

The introduction of laparoscopy or minimal invasive surgery in the early 1990s has revolutionized and ushered in a new era in the field of surgery. The literature is now generally accepted that this minimal invasive approach results in better cosmetic, decreased postoperative pain, less hospital stay, and reduced complication rates compared with open surgery [20, 21]. Moreover, with the help of technological innovations, in order to reduce the invasiveness of the procedures, the surgeons eliminated the need for multiple incisions by performing single-incision techniques. Since Navarra et al. performed the first SALS cholecystectomy in 1995 [7], technique has been described in a wide range of other general surgical procedures including complex bariatric procedures and even pancreaticoduodenectomy [22, 23]. In 2009, our group reported the first single-incision splenectomy and in 2010 the first single-incision laparoscopic distal pancreatectomy [9, 13].

Laparoscopic distal pancreatectomy technique has been performed since the first report by Soper et al. in 1994 which was performed in an animal model [24]. Following that, many surgeons have performed this technique safely in humans [25]. Nowadays, the procedure continues to be performed for benign, malignant [26], and inflammatory lesions [27] and even for harvesting pancreatic donor for transplantation [28] with favorable postoperative outcomes including less pain, shorter hospital stay, better cosmetics, and early return of bowel function [29, 30]. Though conventional multiport laparoscopic pancreas surgery is technically feasible, the SALS procedure is not frequently performed, probably due to the step-learning curve. Thus, majority of reports on SALS pancreatic surgery are often based on limited experience with short-term outcomes. As far as we know, the English literature for SALS performed on pancreatic lesions includes a total of 25 cases [13, 31–33].

SALS technique requires working in line with the camera making movements complex to perform because of instrument crowding. This can be achieved by using articulating instruments, and moreover, ports and instruments of different lengths can be used to make the distance between the surgeon's hands greater, allowing easy maneuver. One of the main concerns is the long operative time. Although operation times have been reported to be significantly longer in laparoscopic pancreas surgery [34], in one of the largest series of 359 patients, Song et al. reported that operative time decreased as surgeon's experience increased as from 4 h at the beginning to 2.5 h at the final quarter of the series [35]. Moreover, in the largest multi-institution series, Kooby et al. reported no differences in operative times between laparoscopic and open distal pancreatectomy groups [5]. Compared to multiport laparoscopic technique, SALS series have similar operative time results ranging from 95 to 330 min in the literature [13, 31].

When we discuss about the indications, one of the primary indications of the technique is pancreatic endocrine neoplasm. The size of the lesion is usually small which makes it suitable to laparoscopic removal [30]. However, because of their small size, they are best localized with intraoperative ultrasound, which can be performed with minimal invasive techniques [33, 36–38]. Small tumors like these, which are separated from the main pancreatic duct, can be enucleated easily, and tumors located in the tail of the pancreas can be treated with a SALS distal pancreatectomy [33].

Indications for conversion include technical problems or oncological properties of the lesion that precluded a safe laparoscopic surgery. Some authors have reported that malignant tumors of pancreas are a contraindication to laparoscopic resection due to the concerns of oncological safety, but there are only limited reports of patients undergoing laparoscopic resections or SALS for pancreas malignities [13, 35, 39, 40]. These reports note similar outcomes of SALS and conventional multiport laparoscopic and open techniques. In one of these reports, Song et al. reported a 91 % R0 resection rate and similar survival rates [35], and in another study, Kooby et al. also reported similar outcomes regarding the margin positivity, operative time, hospital stay, and complications [39]. In our SALS series, we had two cases of pancreatic malignity including a metastatic cancer and an adenocarcinoma. In these cases, we were able to perform the procedure in oncological principles with clear surgical margins.

There are also debates regarding the preservation of spleen, which is another important issue. The recent series report rates of splenic preservation that range from 31 to 85 % in selected cases [41]. Warshaw et al. reported that spleen-preserving technique avoids the splenectomy with all related intra- and postoperative complications [42, 43] and noted that if there is no tumor invasion, the splenic vessels can be spared, and patients do not have any morbidity of sinistral hypertension. However, other authors report little benefit to splenic preservation adding that it is more challenging, takes more time, and increases blood loss [44, 45]. In addition, Benoist et al. reported that pancreatic complications such as fistula or subphrenic abscess occurred more frequently in spleen-preserving technique [46].

Chang et al. reported that the operative time of SALS spleen-preserving distal pancreatectomy procedure was 233 min which is comparable to the average time used for conventional laparoscopic distal pancreatectomy series [47]. In our experience, the preservation of the spleen may take longer to successfully complete and require advanced skills and appropriate instrumentations to compensate the lack of triangulation as in conventional multiport laparoscopic surgery. Moreover, we could achieve to preserve spleen only in one (10 %) case. Thus, we believe that Warshaw's technique is less demanding than the dissection and preservation of the splenic artery and vein. Regarding the conservation of the splenic vessels, we agree with Warshaw [48].

The total complication rate after laparoscopic distal pancreatectomy has been reported between 12 and 40 % with one of the most common and serious complications as postoperative pancreatic leakage [5, 35]. Because the incidence of pancreatic fistula after left pancreatic resection is significant, ranging from 3 to 34 % [49], several trials have investigated ways to prevent pancreatic fistula in laparoscopic distal pancreatectomy. The noted potential factors for the development of pancreatic leak include the technique of pancreatic stump closure, the underlying disease process as chronic pancreatitis and malignant tumors, and concomitant splenectomy. The automatic stapling technique is generally used in laparoscopic distal pancreatectomy for transection of the pancreas [50]. In the Multicenter European Study, it has been reported that pancreas-related complications occurred in 35 % with linear stapling of the pancreas.

As far as we know, Yao et al. reported the largest series of SALS distal pancreatectomy on 11 cases. In terms of postoperative complications, pancreatic leakage occurred in one of these cases, which was ceased spontaneously with only drain during the postoperative period [31]. The author also noted that there were no other complications such as postoperative hemorrhage, venous thrombosis, infections, and so on. In our series of ten SALS distal pancreatectomies, the rate of pancreatic leakage was 30 %; however, these were low-flow pancreatic fistulas, which ceased spontaneously with only drain during the postoperative first month. In addition to pancreatic leakage, we had two other minor complications seen after SALS distal pancreatectomy procedure including gastric atony and small incisional hernia.

Although prospective, randomized trials are lacking, our initial results show that laparoscopic pancreas surgery through a single incision is feasible and safe; however, SALS approach does not have an advantage over the conventional multiport technique except better cosmetic results. As an innovation and advanced laparoscopy center, minimal invasive technique has become our preferred surgical approach.

We believe that in tertiary centers where advanced laparoscopic procedures are performed by experienced hands, this technique may be preferred over the conventional multiport laparoscopic technique.

References

1. Gagner M, Pomp A (1994) Laparoscopic pylorus-preserving pancreatoduodenectomy. Surg Endosc 8:408–410
2. Cushieri A (1994) Laparoscopic surgery of the pancreas. J R Coll Surg Edinb 39:187–194
3. DiNorcia J, Schrope BA, Lee MK et al (2010) Laparoscopic distal pancreatectomy offers shorter hospital stays with fewer complications. J Gastrointest Surg 14:1804–1812
4. Palanivelu C, Shetty R, Jani K et al (2007) Laparoscopic distal pancreatectomy; results of a prospective non-randomized study from a tertiary center. Surg Endosc 21(3):373–377
5. Kooby DA, Gillespie T, Bentrem D et al (2008) Leftsided pancreatectomy: a multicenter comparison of laparoscopic and open approaches. Ann Surg 248:438–443
6. Fernandez-Cruz L, Blanco L, Cosa R (2008) Is Laparoscopic resection adequate in patients with neuroendocrine pancreatic tumors? World J Surg 32:904–917
7. Navarra G, Pozza E, Occhionorelli S et al (1997) One-wound laparoscopic cholecystectomy. Br J Surg 84:695
8. Reavis KM, Hinojosa MW, Smith BR et al (2008) Single-laparoscopic incision transabdominal surgery sleeve gastrectomy. Obes Surg 11:1492–1494
9. Barbaros U, Dinççağ A (2009) Single incision laparoscopic splenectomy: the first two cases. J Gastrointest Surg 13:1520–1523
10. Raman JD, Bagrodia A, Cadeddu JA (2008) Single-incision, umbilical laparoscopic versus conventional laparoscopic nephrectomy: a comparison of perioperative outcomes and short-term measures of convalescence. Eur Urol 5:1198–1204
11. Kong J, Wu SD, Su Y (2013) Translumenal single-incision laparoscopy radical gastrectomy with D2 lymph node dissection for early gastric cancer-primary experience with less invasive surgery in China. J Laparoendosc Adv Surg Tech A 23:141–145
12. Cho CS, Kooby DA, Schmidt CM et al (2011) Laparoscopic versus open left pancreatectomy: can preoperative factors indicate the safer technique? Ann Surg 253:975–980
13. Barbaros U, Sümer A, Demirel T et al (2010) Single incision laparoscopic pancreas resection for pancreatic metastasis of renal cell carcinoma. JSLS 14:566–570
14. Barbaros U, Sümer A, Tunca F et al (2010) Our early experiences with single-incision laparoscopic surgery: the first 32 patients. Surg Laparosc Endosc Percutan Tech 20(5):306–311
15. Deveci U, Barbaros U, Kapakli MS et al (2013) The comparison of single incision laparoscopic cholecystectomy and three port laparoscopic cholecystectomy: prospective randomized study. J Korean Surg Soc 85(6):275–282
16. Vilallonga R, Barbaros U, Sümer A et al (2012) Single-port transumbilical laparoscopic cholecystectomy: a prospective randomised comparison of clinical results of 140 cases. J Minim Access Surg 8(3):74–78
17. Barbaros U, Demirel T, Sumer A et al (2011) SILS incisional hernia repair: is it feasible in giant hernias? A report of three cases. Diagn Ther Endosc 2011:387040
18. Barbaros U, Demirel T, Gozkun O et al (2011) A new era in Minimally Invasive Liver Resection (MILR) Single-Incision Laparoscopic Liver Resection (SIL-LR): the first two cases. Surg Technol Int 1(XXI):81–84
19. Barbaros U, Demirel T, Sumer A et al (2011) Pure SILS Floppy Nissen Fundoplication with hiatal repair: a case report. ISRN Gastroenterol 2011:347487
20. Johansson M, Thune A, Nelvin L et al (2005) Randomized clinical trial of open versus laparoscopic cholecystectomy in the treatment of acute cholecystitis. Br J Surg 92:44–49
21. Bilimoria KY, Bentrem DJ, Merkow RP et al (2008) Laparoscopic-assisted vs. open colectomy for cancer: comparison of short-term outcomes from 121 hospitals. J Gastrointest Surg 12:2001–2009
22. Greaves N, Nicholson J (2011) Single incision laparoscopic surgery in general surgery: a review. Ann R Coll Surg Engl 93:437–440
23. Palanivelu C, Jani K, Senthilnathan P et al (2007) Laparoscopic pancreaticoduodenectomy: technique and outcomes. J Am Coll Surg 192:257–261
24. Soper NJ, Brunt LM, Dunnegan DL et al (1994) Laparoscopic distal pancreatectomy in the porcine model. Surg Endosc 8(1):57–61

25. Cuschieri SA, Jakimowicz JJ (1998) Laparoscopic pancreatic resections. Surg Innov 5(3): 168–179
26. Kooby DA, Chu CK (2010) Laparoscopic management of pancreatic malignancies. Surg Clin N Am 90(2):427–446
27. Fisichella PM, Shankaran V, Shoup M (2010) Laparoscopic distal pancreatectomy with or without splenectomy: how i do it. J Gastrointest Surg 15(1):215–218
28. Maruyama M, Kenmachi T, Akutsu N et al (2010) Laparoscopic assisted distal pancreatectomy and nephrectomy from a live donor. J Hepato-Biliary-Pancreat Sci 17(2):193–196
29. Fabre JM, Dulucq JL, Vacher C et al (2002) Is laparoscopic left pancreatic resection justified? Surg Endosc 19:507–510
30. Patterson EJ, Gagner M, Salky B et al (2001) Laparoscopic pancreatic resection: single-institution experience with 19 patients. J Am Coll Surg 193:281–287
31. Yao D, Wu S, Tian Y (2014) Transumbilical single-incision laparoscopic distal pancreatectomy: primary experience and review of the English literature. World J Surg 38(5):1196–1204
32. Chang SKY, Lomanto D, Mayasari M (2012) Single-port laparoscopic spleen preserving distal pancreatectomy. Minim Invasive Surg 2012:197429
33. Srikanth G, Shetty N, Dubey D (2013) Single incision laparoscopic distal pancreatectomy with splenectomy for neuroendocrine tumor of the tail of pancreas. J Minim Access Surg 9(3): 132–135
34. Aly MY, Tsutsumi K, Nakamura M et al (2010) Comparative study of laparoscopic and open distal pancreatectomy. J Laparoendosc Adv Surg Tech A 20:435–440
35. Song KB, Kim SC, Park JB (2011) Single-center experience of laparoscopic left pancreatic resection in 359 consecutive patients: changing the surgical paradigm of left pancreatic resection. Surg Endosc 25:3364–3372
36. Pierce RA, Spitler JA, Hawkins WG et al (2006) Outcomes analysis of laparoscopic resection of pancreatic neoplasms. Surg Endosc 21:579–586
37. Avay A, Bresler L, Brunaud L et al (2000) Laparoscopic approach for solitary insulinoma: a multicenter study. Langenbecks Arch Surg 390(2):134–140
38. Spitz JD, Lilly MC, Tetik C et al (2000) Ultrasoundguided laparoscopic resection of pancreatic islet cell tumors. Surg Laparosc Endosc Percutan Tech 10(3):168–173
39. Kooby DA, Hawkins WG, Schmidt CM et al (2010) A multicenter analysis of distal pancreatectomy for adenocarcinoma: is laparoscopic resection appropriate? J Am Coll Surg 210:776–779
40. Shoup M, Conlon KC, Klimstra D et al (2003) Is extended resection for adenocarcinoma of the body or tail of the pancreas justified? J Gastrointest Surg 7:946–952
41. Taylor C, O'Rouke N, Nathanson L et al (2008) Laparoscopic distal pancreatectomy: the Brisbane experience of forty-six cases. HPB 10:38–42
42. Cruz LF, Orduna D, Cesar-Borges G (2005) Distal pancreatectomy: en-bloc splenectomy vs spleen-preserving pancreatectomy. J Int Hepato Pancreato Biliary Assoc 7(2):93–98
43. Lee SE, Jang JY, Lee KU (2008) Clinical comparison of distal pancreatectomy with or without splenectomy. J Korean Med Sci 23(6):1011–1014
44. Richardson DQ, Scott-Conner CE (1989) Distal pancreatectomy with and without splenectomy: a comparative study. Am Surg 55:21–25
45. Aldirge MC, Williamson RCN (1991) Distal pancreatectomy with and without splenectomy. Br J Surg 78:976–979
46. Benoist S, Dugue L, Sauvanet A (1999) Is there a role of preservation of the spleen in distal pancreatectomy? J Am Coll Surg 188:255–260
47. Nigri GR, Rosman AS, Petrucianni (2010) Metaanalysis of trials comparing minimally invasive and open distal pancreatectomies. Surg Endosc 25(5):1642–1652
48. Warshaw A (1997) Letter to the editor. Techniques of preserving the spleen with distal pancreatectomy. Surgery 121:974
49. Balzano G, Zerbi A, Cristallo M (2005) The unsolved problem of fistula after pancreatectomy: the benefit of cautions drain management. J Gastrointest Surg 9:837–842
50. Takenchi K, Tsuzuki Y, Ando T (2003) Distal pancreatectomy: is staple closure beneficial? Aust N Z J Surg 73:922–925

12 Single-Access Laparoscopic Liver Resections

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12.1 Introduction

With a certain delay compared to other surgical areas, the minimally invasive approach has also been extended to liver surgery albeit with initial hesitations related to the well-known technical features that characterize liver surgery and doubts about adequate oncological radicality. Numerous case series, comparative studies, and meta-analyses have progressively demonstrated the feasibility, safety, and reproducibility of the minimally invasive approach to liver resections, as well as the non-inferiority compared to the open technique in terms of oncological outcomes, for both benign and malignant neoplasms [1, 2]. Moreover, the application of minimally invasive approach to liver resections was found to be associated with clinical benefits, particularly in terms of reducing blood loss and the subsequent need for transfusion and rapid functional recovery [3, 4]. In addition, certain categories of patients undergoing liver resection have been shown to particularly benefit from the advantages of the laparoscopic approach. In particular, cirrhotic patients undergoing laparoscopic liver resection for hepatocellular carcinoma appear to be less prone to liver failure and ascitic decompensation in the postoperative period than patients undergoing open resection [5]. In addition, patients with liver metastases often require repeated liver resections and can benefit from reduced postsurgical adhesion that develops as a result of minimally invasive approach, thus favoring reintervention [6]. On this evidence and on the basis that standard laparoscopic hepatectomy entails the use of three to six ports and a skin incision to extract the specimen, in the last few years, the single-incision laparoscopic technique has been extended to liver resections in order to minimize the number of

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_12,

incisions. As for other surgical procedures, such cholecystectomies and appendectomies, the search for even less invasive methods has the aim of further reducing surgical stress and postoperative pain with consequent favorable impact on surgical outcome, in addition to the cosmetic benefit. Furthermore, port-related complications such as organ damage, adhesions, bleeding, wound infections, and hernias could be decreased.

The first case reports about single-port approach in liver surgery have been published in 2010 and showed the feasibility of cysts unroofing with acceptable intra- and postoperative outcomes, even when combined to other procedures as cholecystectomies [7–9]. Subsequently, several case reports have documented the completion of some isolated partial hepatectomies through single-port laparoscopy. The technique proved to be technically demanding but applicable for partial hepatectomy as far as the benefits of cosmesis, hospital stay, postoperative pain, and convalescence are concerned, especially if performed by teams already familiar with the technique applied to other surgical procedures [10–12]. Some case series have been published with the purpose of clarifying the reproducibility, the indications, and the possible effects of this technique on long-term outcomes and in order to determine its potential position among other minimally invasive techniques for liver resection.

12.2 Surgical Technique

From a technical standpoint, the patient is usually placed in reverse Trendelenburg position with legs apart (the French position) and the first surgeon standing between the legs. Some authors prefer the standard supine position for left liver surgery and left semilateral or lateral decubitus for right liver manipulation with the surgeon standing on the right side of the patient and the assistant on the left [13, 14]. Generally, an umbilical or supraumbilical midline incision is performed, with the location of the incision varying slightly from patient to patient depending on the body types and exact location of the lesion (Fig. 12.1). Both three and four access ports can be used, and the size of the incision is dependent on the port adopted, varying from 2 to 5 cm [15, 16].

The majority of the authors describe the use of tools and the choice of a surgical technique very similar to the standard laparoscopic technique, with the difference that is performed through a single access [17–19]. Both 30° and linear 5–10 mm laparoscopes can be used to explore the peritoneal cavity. Then multiple instruments are simultaneously introduced in the abdominal cavity that generally consist of a tool for dissection along with one or more grasps or devices for aspiration (Fig. 12.2). The major technical difficulty in the execution of procedures through single-port technique is related to the parallel position that the devices mutually assume and the consequent loss of triangulation with the optical system, which limits considerably the possibilities of movement and the field of action. Therefore, some authors suggest the use of curved instruments specifically designed so as to obtain adequate exposure and triangulation, which can be an alternative to

Fig. 12.1 An umbilical or supraumbilical midline incision is generally performed for LESS liver resections, with the location of the incision varying depending on the body types and topography of the lesion

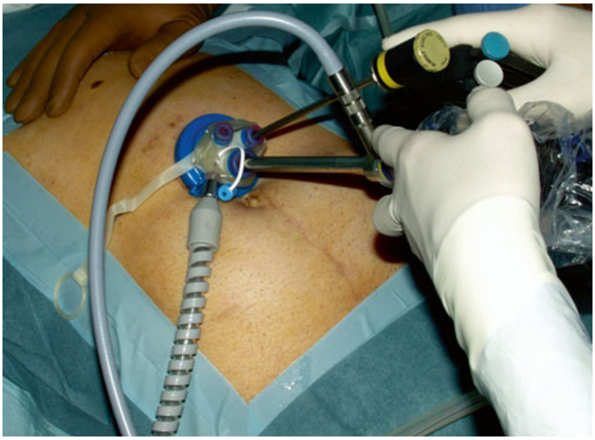

Fig. 12.2 Multiple instruments are simultaneously introduced in the abdominal cavity through the LESS device, generally consisting of a dissection tool along with one or more grasps or devices for aspiration

overcome this technical difficulty [20]. However, in the majority of cases, the use of straight laparoscopic instruments has been adopted, thus enabling the execution of these procedures without an increase in costs compared to traditional laparoscopy. Moreover, the adoption of standard laparoscopic instruments may shorten the surgeon's learning curve in the acquisition of skills in the new single-port technique. As well as in open surgery, various methods and instruments for parenchymal transection during single-port liver resection are described, mostly corresponding to the methods adopted at individual centers for traditional laparoscopic liver resections. The methods for parenchymal transection generally preferred are ultrasound and radiofrequency-based devices [19–21]. As well as in open and laparoscopic surgery, the section of larger portal pedicles and hepatic branches can be managed through the use of articulating linear staplers. The single-port technique also allows the execution of intraoperative ultrasonography with a flexible laparoscopic ultrasound probe [14, 22]. The intraoperative ultrasound routinely performed before parenchymal transection allows the operator to identify precisely the location of the lesion and to plan the line of transection, which may be marked on the liver surface using diathermy. During parenchymal transection, the repeated use of intraoperative ultrasonography allows to ride along a transection plan oncologically adequate.

12.3 Discussion

The published series show the possibility to perform liver resections by single-port access without the need for conversion to traditional laparoscopy or open surgery. The conversion rate reported in literature ranges between 0 and 16.7 % [18, 20]. Adding further trocar to the device is not required to praxis but can be useful in case of need for better exposure of the operative field or for the management of complications. This occurrence may be necessary, in particular if using three-way single-port devices (Fig. 12.3) [19].

Regarding intraoperative outcomes, the published series showed reduced blood loss and operating time and comparable to those obtained with traditional laparoscopic approach to hepatectomy (80.4–205 min, 2–500 mL) [14, 15]. As well as in traditional surgery, even for single-port hepatectomies, blood losses and operating times are closely related to the technique for transection, the occurrence of complications, the extent of resection, and the expertise of the operator, which implies certain variability with the completion of the learning curve.

The extraction of the surgical specimen can be carried out through the incision made for the insertion of the single-port device, after insertion in a suitable plastic bag retrieval, thus avoiding in most cases the need for additional abdominal wounds (Fig. 12.4) [20]. In case of benign neoplasms, the specimen can be broken up so as to avoid the need to expand the access for the extraction. In case of hepatectomy for malignant disease, for which the evaluation of the surgical margin and the integrity of the anatomical part are fundamental, it is possible to extend slightly the

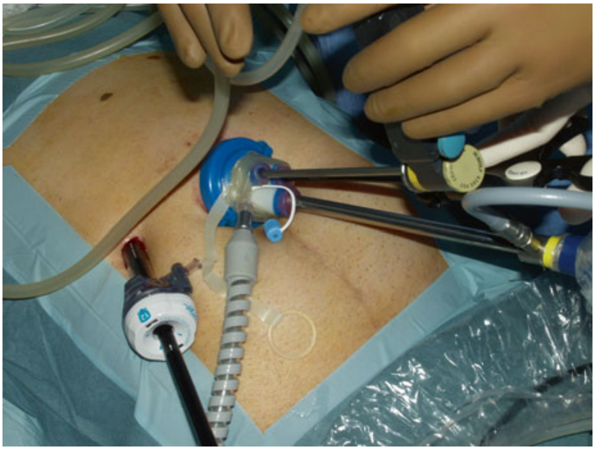

Fig. 12.3 Adding further trocar to the single-port device can be useful for better exposure of the operative field or for the management of intercurrent complications, in particular if using three-way single-port devices

Fig. 12.4 The extraction of the surgical specimen can be carried out through the incision made for the insertion of the single-port device, thus avoiding in most cases the need for additional abdominal wounds

abdominal incision so as to remove the sample [11]. Therefore, it seems sensible to identify optimal candidates for the technique as patients affected by liver lesions smaller than 5 cm, so as not to dissolve the advantages related to the minimally invasive access. Some authors also recommend that the patient is not taller than 180 cm or suffering from obesity because in these cases the traditional laparoscopic instrumentation is not sufficiently long when inserted. Anyway, the single-port approach has already been reported to be safe and effective for bariatric surgery; therefore, obesity should not be considered an absolute contraindication in patients who are candidates to hepatectomy [23]. When considering the single-port approach, it should be rather argued that a thicker abdominal wall would lead to increased technical complexity because of instrument conflict at the fulcrum point. Another important criterion for the selection of patients seems to be the location of the lesions within the liver parenchyma. To be within reach of the laparoscopic instrumentation, hepatic lesions should be localized within laparoscopic segments (i.e., segments 2, 3, 4b, 5, 6), while lesions of the cranial and the first segment are not optimal candidates for a workable procedure. In this regard, at present, the best indication for the use of the single-port laparoscopy seems to be left lateral sectionectomy, because the transection line is in front of the device and significant triangulation of the instrument is not needed. In fact, the suspensory ligaments (round and falciform ligaments, left coronary and triangular ligaments) of the liver help the surgeon with the surgical field exposure, and in-line view is not a major issue to deal with [18]. The comparative analysis of a series of left lobectomy found that the single-port approach to liver resection is feasible, safe, and at least not inferior to the standard laparoscopic resection in terms of complications and clinical outcomes [24].

With respect to the postoperative course, most of the series in the literature describe a rapid return of patients to full functional recovery, reduced need for analgesics, and limited postoperative complications. The majority of patients were able to walk unassisted on the first postoperative day and could be discharged from the second postoperative day [14, 20, 24].

The series in the literature describe the feasibility of the single-port technique for the resection of both benign and malignant liver lesions. Actually, there are no studies in the literature showing the oncological outcomes in the medium to long-term for patients undergoing this type of procedure. However, the surrogate endpoints (i.e., the infiltration of the surgical margin) evaluated in some of the published series show the adequacy of the procedure from the oncological standpoint [14, 19].

Finally, the preliminary experience present in the literature with liver resection via a single-port access suggests its technical feasibility and safety in terms of intra- and postoperative results without any compromise in oncological safety for selected patients. Better cosmesis and pain control seem to be so far the main benefits for a patient undergoing single-port surgery. In addition to these advantages, single-port approach has the potential advantages to reduce other complications related to surgical accesses, such as bleeding, internal organ damage, wound infection, and wound pain, even if these differences are not highlighted in the studies present in the literature. Although it seems feasible, this approach needs caution and should be initially reserved to minor resection in highly selected patients and should be undertaken only with proper training and in high-volume centers by surgeons with expertise in both liver and advanced laparoscopic surgery. Further studies are needed in order to determine this method's potential position among other minimally invasive liver resection techniques.

References

1. Nguyen KT, Laurent A, Dagher I et al (2009) Minimally invasive liver resection for metastatic colorectal cancer: a multi-institutional, international report of safety, feasibility, and early outcomes. Ann Surg 250:842–848
2. Abu Hilal M, Underwood T, Zuccaro M et al (2010) Short- and medium-term results of totally laparoscopic resection for colorectal liver metastases. Br J Surg 97:927–933
3. Pulitanò C, Aldrighetti L (2008) The current role of laparoscopic liver resection for the treatment of liver tumors. Nat Clin Pract Gastroenterol Hepatol 5:648–654
4. Mirnezami R, Mirnezami AH, Chandrakumaran K et al (2011) Short- and long-term outcomes after laparoscopic and open hepatic resection: systematic review and meta-analysis. HPB (Oxford) 13:295–308
5. Zhou YM, Shao WY, Zhao YF et al (2011) Meta-analysis of laparoscopic versus open resection for hepatocellular carcinoma. Dig Dis Sci 56:1937–1943
6. Castaing D, Vibert E, Ricca L et al (2009) Oncologic results of laparoscopic versus open hepatectomy for colorectal liver metastases in two specialized centers. Ann Surg 250:849–855
7. Mantke R, Wicht S (2010) Single-port liver cyst fenestration combined with Single-port laparoscopic cholecystectomy using completely reusable instruments. Surg Laparosc Endosc Percutan Tech 20:28–30
8. Sasaki K, Watanabe G, Matsuda M et al (2010) Original method of transumbilical single-incision laparoscopic deroofing for liver cyst. J Hepatobiliary Pancreat Sci 17:733–734
9. Cai W, Xu J, Zheng et al (2012) Combined laparoendoscopic single-site surgery: initial experience of a single center. Hepatogastroenterology 59:986–989
10. Hu M, Zhao G, Xu D et al (2011) Transumbilical single-incision laparoscopic hepatectomy: an initial report. Chin Med J 124:787–789
11. Belli G, Fantini C, D'Agostino A et al (2010) Laparoendoscopic single site liver resection for recurrent hepatocellular carcinoma in cirrhosis: first technical note. Surg Laparosc Endosc Percutan Tech 21:166–168

12. Aldrighetti L, Guzzetti E, Ferla G (2011) Laparoscopic hepatic left lateral sectionectomy using the laparoendoscopic single site approach: evolution of minimally invasive liver surgery. J Hepatobiliary Pancreat Sci 18:103–105
13. Pan M, Jiang Z, Cheng Y et al (2012) Single-incision laparoscopic hepatectomy for benign and malignant hepatopathy: initial experience in 8 Chinese patients. Surg Innov 19:446–451
14. Shetty GS, You YK, Choi HJ et al (2012) Extending the limitations of liver surgery: outcomes of initial human experience in a high-volume center performing single-port laparoscopic liver resection for hepatocellular carcinoma. Surg Endosc 26:1602–1608
15. Aikawa M, Miyazawa M, Okamoto K et al (2012) Single-port laparoscopic hepatectomy: technique, safety, and feasibility in a clinical case series. Surg Endosc 26:1696–1701
16. Chang SK, Mayasari M, Ganpathi IS et al (2011) Single port laparoscopic liver resection for hepatocellular carcinoma: a preliminary report. Int J Hepatol 2011:579203
17. Tan EK, Lee VT, Chang SK et al (2012) Laparoendoscopic single-site minor hepatectomy for liver tumors. Surg Endosc 26:2086–2091
18. Gaujoux S, Kingham TP, Jarnagin WR et al (2011) Single-incision laparoscopic liver resection. Surg Endosc 25:1489–1494
19. Cipriani F, Catena M, Ratti F et al (2012) LESS technique for liver resection: the progress of the mini-invasive approach: a single-centre experience. Minim Invasive Ther Allied Technol 21:55–58
20. Zhao G, Hu M, Liu R et al (2011) Laparoendoscopic single-site liver resection: a preliminary report of 12 cases. Surg Endosc 25:3286–3293
21. Dapri G, Dimarco L, Cadière GB et al (2012) Initial experience in single-incision transumbilical laparoscopic liver resection: indications, potential benefits, and limitations. HPB Surg 2012:921973
22. Røsok BI, Edwin B (2011) Single-incision laparoscopic liver resection for colorectal metastasis through stoma site at time of reversal of diversion ileostomy: a case report. Minim Invasive Surg 2011:502176
23. Koh CE, Martin DJ, Cavallucci DJ et al (2011) On the road to single-site laparoscopic adjustable gastric banding: lessons learned from 60 cases. Surg Endosc 25:947–953
24. Aldrighetti L, Ratti F, Catena M et al (2012) Laparoendoscopic single site (LESS) surgery for left-lateral hepatic sectionectomy as an alternative to traditional laparoscopy: case-matched analysis from a single center. Surg Endosc 26:2016–2022

Single-Access Laparoscopic Approach for Gynecological Surgery

13

G. Corrado, G. Pomati, S. Sindico, and E. Vizza

13.1 Introduction

In the last decades, minimally invasive surgery has been widely applied in many surgical specialties, and laparoscopic surgery has assumed an increasingly central role in gynecology. The published literature about minimally invasive surgery has shown the benefits achieved in terms of surgical outcomes, cost, quality of life, reduced morbidity, shorter hospital stay, and, accordingly, a quick return to daily activities [1]. In the last year, it has been possible to complete a large number of complex surgical procedures, thanks to important technical improvements. Lately, the concept of laparoscopic surgery has been revised through the introduction of the laparoendoscopic single-site surgery (LESS). The term "single site" describes the use of a single small skin incision instead of the multiple accesses created in conventional laparoscopy [2]. According to many studies, reducing the number of the ports created in the abdominal wall, it is possible to improve the cosmetic results and decrease the morbidity and complications, such us hernias, infection, and nerves injuries [3]. One of the first applications of the LESS was in 1969, when Wheeless [4] applied it in sterilization. Then, in 1991, Pelosi and Pelosi [5] completed the first hysterectomy with salpingo-oophorectomy. However, only in the last years LESS has become effective, safe, and feasible in the completion of complex surgical procedures in gynecology. In the same time, LESS has taken a leading role also in other surgical specialties, such us urology [6, 7], and it is applied in much complex surgery, such us appendicectomy [8], cholecystectomy [9], and colectomy [10]. Over the years, the technical development in instrumentation has allowed to overcome some challenges, making LESS safe for the patients.

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_13,

13.2 LESS Devices

In conventional laparoscopy, every port allows the insertion of a single laparoscopic instrument. In LESS, there are three different ways to create the abdominal access. At the beginning, an operative laparoscope, able to perform the tubal ligation, was used in the sterilization. Another way was the passage of instrument through multiple incisions created in the fascia. In this case, the application of small ports, provided with an anchor (AnchorPort), could be of help in maintaining the stability during the induction of pneumoperitoneum. Recently, new devices have been introduced in order to allow the passage of multiple instruments through a single skin incision, and, actually, different types of LESS devices exist and are currently used. The SILS port (Covidien) necessitates a fascial incision of 1.8–3 cm and has four channels: the first is used for gas insufflation, while the other three ports are used for the insertion of different instruments. The SILS port belongs to the SILS kit which has several benefits: it consists of roticulator instruments with a limited degree of movement, but cheaper than other instruments available in commerce. Moreover, the SILS port minimizes the gas loss through the port. The TriPort (Olympus) is a single-port access consisting of two rings, one inner and the other one outer, and an intervening plastic sleeve. The internal ring is placed into the abdominal cavity, while the outer ring is sealed to the abdominal wall. The application of the TriPort can help to minimize the gas loss, maintaining the pneumoperitoneum, and to decrease the instruments' collision, thanks to an optimal angle between the ports. Unlike the TriPort, the QuadPort consists of four ports. The GelPOINT consists of a wound retractor (Alexis wound retractor) and a cap (GelSeal) and allows the creation of four ports, three of 5 mm and one of 10 mm. Once the wound retractor, consisting of two rings, one inner and the other one outer, and an intervening sleeve, is placed through a skin incision of 1.5–7 cm, the cap can be applied on the external ring. The gel cap makes possible the insertion of the instrument in the most suitable configuration for the surgeon. The AirSeal Access induces the pneumoperitoneum using a continuous gas insufflation. The high gas pressure in the abdomen keeps the device tight to the abdominal wall. This device allows an easy insertion of the instruments. On the other hand, the open device makes difficult to maintain the stability of the instruments.

13.3 Learning Curve

In the last years, several studies have shown that LESS is a safe surgical approach in the treatment of many kinds of gynecological disease. In view of what has just been said, we need a thorough discussion about the surgeon's learning curve. In Escobar's study [44], the operative time has been correlated to number of treated cases unexpectedly resulting in a learning curve of 10–15 cases. Probably, the short learning curve could depend by a reduced amount of time spent to close the single port in the end of the procedure and, above all, by the surgeon's experience. As a matter of fact, the achievement of a wide experience in conventional laparoscopic surgery could contribute to make learning curve shorter. Fader et al. [23] calculated the mean operative time for total hysterectomy and salpingo-oophorectomy in order to describe the surgeon's learning curve. The mean operative time to introduce the device was 9.2 min in the first 10 cases, 4.8 min from case 11 to 20, and 4.3 min from case 21 to 31. The mean operative time required for the total hysterectomy and salpingo-oophorectomy was of 79.4 min from case 1 to 10 and 56.8 min from case 11 to 20. In both cases, the most significant reduction in operative time was detected after the first 10 cases, but the value stabilized only after 20 cases. These findings are very similar to those of the conventional laparoscopy. However, it should be calculated a learning curve specifically for each kind of procedures and with a great number of cases to validate the results. Every surgeon should start to perform simple procedures, because, in this way, it is possible to make the learning curve shorter as he/she becomes more familiar with the surgical technique and instruments. The major difficulties are the adaptation with in-line instrument and the lack of triangulation, even if a surgeon's wide experience in conventional laparoscopy might help to overcome some technical challenges.

13.4 Benign Diseases

In recent years, single-site surgery has been applied in benign disease to a number of surgical procedures including hysterectomy, adnexal surgery, and myomectomy. Several studies have highlighted the improvement in terms of surgical outcomes, cosmesis, and postoperative pain. Table 13.1 shows some of the several studies published to date about the LESS application in gynecological benign disease. As shown by some reports [11, 12], LESS has been successfully applied in the treatment of ectopic pregnancy with good results in terms of blood loss, complication, hospital stay, postoperative pain, and cosmesis. In two studies [30, 37] (Table 13.1), two minimally invasive techniques, LESS and traditional laparoscopy, were compared in the treatment of ectopic pregnancy, resulting in similar surgical outcomes. In one of these two studies [30], no differences were found between LESS and laparoscopy in operative time (52.6 vs 46.8), hemoglobin drop (1.7 vs 1.8), and hospital stay (2.4 vs 2.4). Several reports [15, 18, 20, 21, 24–26, 31, 33, 36, 39, 41, 42] described the role of LESS in the treatment of myomatosis, adenomyosis, and uterine fibroid. Kim et al. [21] reported good results in 15 LESS myomectomy. As a matter of fact, all the myomectomy were completed and no intraoperative and postoperative complication occurred. The operative time was 96.7 min, the hemoglobin drop was 1.8 g/dl, and the hospital stay was 3.1 days. Song et al. [24] described the LESS-assisted vaginal hysterectomy with large uterus (>500). The operative time and the blood loss were 125 min and 500 ml, respectively. No complications occurred, but during two procedures, an additional trocar was inserted. All the results confirmed the safety in feasibility of LESS in the surgical treatment of myomatosis. Moreover, Chen et al. [31], in a randomized controlled trial, compared single-port and laparoscopic-assisted vaginal hysterectomy in women with myomatosis, resulting in similar surgical outcomes, and in cases treated in single-site

Table 13.1 LESS procedure in benign gynecological diseases

Authors	Year	Type of study	Patients	Pathology	Median OT (min)	Median EBL (ml)	Median Hb drop (g/dl)	IOC	POC	Median Hs (days)	Conversion
Lim et al. [13]	2009	Prospective	12	Benign adnexal tumors	73 (25–110)	10	NR	0	0	2 (2–3)	0
Kim et al. [14]	2009	Prospective	23	Adnexal masses	70 (40–128)	10 (10–100)		0		1 (1–3)	1
Lee et al. [15]	2009	Prospective	24	Myomas and adenomyosis	119 (90–255)	400 (100–1000)	NR	0	0	3 (3–7)	3
Fader et al. [16]	2009	Retrospective	4	Benign adnexal disease	47.5 (40–60)	NR	NR	0	0	0.5	0
Yoon et al. [12]	2010	Prospective	20	Ectopic pregnancy	55 (25–85)	NR	1.8 (0.3–2)	0	0	3 (2–4)	0
Lee et al. [17]	2010	Prospective, case control	17	Benign adnexal tumors	64 (33–148)	80 (10–200)	NR	0	0	2 (1–4)	0
Kim et al. [18]	2010	Retrospective, case control	43	Leiomyoma and adenomyosis	119 ± 32	369 ± 312	NR	0	0	2.8 ± 0.9	4
Yim et al. [19]	2010	Retrospective, comparative	52	Benign gynecological condition	117 (54–195)	100 (20–600)	NR	0	4	3.4	0
Jung et al. [20]	2010	Randomized prospective	34	Uterine fibroid, preinvasive cervical disease, adnexal lesions	89 ± 25.4	NR	NR	1	10	3.4 (3–4.3)	4
Kim et al. [21]	2010	Prospective	15	Myomas	96.7 (35–150)	NR	1.8 (0.4–3.6)	0	0	3.1 (0.8;2–4)	0
Escobar et al. [22]	2010	Case report	9	Benign adnexal pathology	NR	0–75	NR	0	0	1	1
Fader et al. [23]	2010	Retrospective	48	Benign pelvic mass and endometrial hyperplasia	43	25 (5–300)	NR	0	2	0 (0–3)	0

Song et al. [24]	2010	Prospective	15	Adenomyomas and myomas	125 (80–236)	500 (150–1,000)	NR	0	0	ND	2
Yoon et al. [25]	2010	Prospective	7	Myomas and adenomyomas	157 (140–233)	200 (100–300)	NR	0	0	4 (3–4)	0
Paek et al. [26]	2011	Retrospective	100	Benign disease (uterine and ovarian)	80 (41–185)	50 (10–600)	NR	0	8	3 (2–10)	0
Bedaiway et al. [11]	2011	Prospective	11	Ectopic pregnancy	35 (25–65)	30 (5–50)	NR	0	ND	8 (5–18)	0
Fagotti et al. [27]	2011	Prospective	28	Benign adnexal disease	39.5 (18–118)	10 (5–150)	NR	0	0	1.3 ± 0.5	2
Kim et al. [28]	2011	Retrospective	88	Benign disease	50.33 ± 13.26	42.83 ± 42.59	NR	6	2	1.94 ± 0.45	1
Fagotti et al. [29]	2011	Prospective, case control	27	Adnexal disease	38.5 (20–115)	20 (10–150)	NR	2	1	1 (1–3)	2
Yoon et al. [30]	2011	Prospective, case control	30	Ectopic pregnancy	52.6 ± 16.1	NR	1.7 ± 0.8	0	0	2.4 ± 0.5	0
Chen et al. [31]	2011	Prospective, randomized control trial	50	Benign pathology (leiomyoma, adenomyosis, endometrial hyperplasia, preinvasive cervical neoplasia)	122 ± 40	146 ± 124.8	NR	0	1	3.7 ± 0.7	2
Fagotti et al. [32]	2011	Prospective, randomized control trial	30	Benign adnexal disease	52	9.2	NR	0	1	1.3	0
Fanfani et al. [41]	2012	Retrospective cohort	14	Myoma, endometrial hyperplasia, adnexal masses	105 (75–125)	30 (10–80)	NR	1	0	1 (1–3)	1

(continued)

Table 13.1 (continued)

Authors	Year	Type of study	Patients	Pathology	Median OT (min)	Median EBL (ml)	Median Hb drop (g/dl)	IOC	POC	Median Hs (days)	Conversion
Hoyer-Sorensen et al. [34]	2012	Prospective	40	Benign adnexal disease	42	50	NR	0	2	NR	NR
Cho et al. [35]	2012	Prospective randomized controlled study	33	Adnexal cyst	42.1	NR	2	0	2	ND	0
Han et al. [36]	2012	Prospective observational study	10	Uterine fibroids	196 (129–248.8)	100 (30–212.5)	NR	0	0	3 (2–4.3)	0
Kim et al. [37]	2013	Retrospective	63	Ectopic pregnancy	48.5 ± 10.6		1.4 ± 0.5	0	1	3.5 ± 0.9	0
Yim et al. [38]	2013	Retrospective, comparative	110	Benign adnexal disease	57.5 (41–91.3)	5 (5–50)	NR	0	4	2.1	NR
Choi et al. [39]	2013	Retrospective, comparative	120	Benign gynecological disease	73.1 ± 24.3 (35–180)	NR	1.7 ± 0.8 (0.2–4.4)	10	10	NR	0
Yoo et al. [40]	2013	Prospective	38	Benign adnexal mass	68 (45–180)	NR	2	0	1	NR	1
Fanfani et al. [33]	2013	Prospective randomized trial	17	Myoma, endometrial hyperplasia, adnexal masses	120 (55–155)	30 (10–300)	NR	0	0	2 (1–5)	2
Li et al. [42]	2013	Prospective randomized trial	52	Myomas	130.6 ± 15.2 (101.14–147.32)	158.27 ± 51.6 (70.01–270.23)	NR	0	13	5 ± 0.89 (4–7)	1

OT operative time, *EBL* hematic blood loss, *Hb* hemoglobin, *IOC* intra operative complication, *POC* post operative complications, *NR* not reported surgery, a less dose of postoperative analgesicswwas required. A great number of studies [13, 14, 16, 17, 20–23, 26–29, 32–35, 38–41, 43] showed data about the performance of LESS adnexal surgery, including procedures such as cystectomy, salpingo-oophorectomy, and oophorectomy. In the prospective study of Kim et al. [14], 24 benign adnexal masses were treated in LESS. Twenty-two procedures were successfully completed and two conversions occurred, but one of these cases was a borderline ovarian tumor. There were no complications, the blood loss was minimal, and the hospital stay was only 1 day. Later, also Fagotti et al. [27] completed a report of 28 cases of benign adnexal disease treated by LESS, showing optimal surgical outcomes. Postoperative pain analysis in this report confirmed a need for analgesic therapy in less than one-third of the cases. In another study of Kim et al. [28], adnexal benign tumors were the target resulting in good surgical outcomes. Moreover, this preliminary study indicated that LESS is feasible and safe in patients who have undergone earlier abdominal surgery ($n=27$). Most of the more recent studies [17, 29] have compared LESS and traditional laparoscopy, especially in the treatment of adnexal disease, in terms of surgical outcomes, postoperative pain, and cosmetic results. Two randomized trials [32, 34], comparing LESS and traditional laparoscopy in the adnexal surgery, showed in the LESS group a higher satisfaction for cosmetic results and postoperative pain but similar surgical outcomes. Altogether, these recent reports prove that LESS is a safe and feasible alternative to laparoscopy in treatment of benign conditions, especially considering the good cosmetic results that can be guaranteed to younger women.

13.5 Malignant Diseases

In the last decade, minimally invasive surgery has been widely introduced in the management of the gynecological malignant disease. As a matter of fact, the role of LESS in gynecological oncology is well established, but it continues to evolve. In particular, in the last years, published studies have shown the excellent application of the LESS above all in the treatment of early stage endometrial cancer. Table 13.2 shows the surgical outcomes achieved in some of the major studies published to date. Fader AN in 2009 [16] described his results about the treatment of five cases including endometrial cancer, granulosa cell ovarian cancer, and risk-reducing performances for woman treated for breast cancer or for BRCA mutations. All the procedures were successfully performed in LESS, without any intraoperative and postoperative complications and with a short hospital stay (1 day). Furthermore, no analgesics were required postoperatively, showing a decrease in postoperative pain. Another Fader's study [23], presenting 26 cases including endometrial cancer, ovarian cancer, and others cancers, showed, also in this case, a low complication rate (3 %) and low blood loss (100 ml), but three conversions to laparotomy or conventional laparoscopy. Moreover, operative time seemed to decrease with surgeon's experience, increasing number of performed cases. Boruta's study [46] analyzed the surgical outcomes of five endometrial cancer cases treated with LESS, showing excellent results in terms of blood loss

Table 13.2 LESS procedure in malignant gynecological diseases

Authors	Year	Type of study	Patients	Pathology	Stage	Median OT (min)	Median EBL (ml)	Median Lymph nodes	IOC	POC	Median Hs (days)	CV
Kim et al. [14]	2009	Prospective	1	Borderline ovarian tumor	NR	70 (40–128)	10 (10–100)	NR	0	0	1 (1–3)	1
Fader et al. [16]	2009	Retrospective	5	Endometrial and ovarian cancer, complex pelvic mass	IB endometrial cancer (1), IA granulosa cell tumor (1), IV breast cancer + BRCA1 (3)	105 (35–175)	NR	NR	0	0	1	0
Fader et al. [23]	2010	Retrospective	26	Endometrial (15), ovarian cancer (6), others (5)	Early stage endometrial and ovarian cancer	132	100 (10–500)	PL = 9 (7–2) endometrial cancer, PL = 3 (2–6) ovarian cancer	0	1	1 (0–6)	3
Escobar et al. [44]	2010	Retrospective	58	BRCA1 +	NR	38.1 (16–80)	NR	NR	0	3	1	0
Escobar et al. [45]	2010	Prospective	21	Endometrial cancer (14), ovarian cancer (4), cervical cancer (3)	Early	120 (60–185)	0–100	Pl = 14 (7–19) PAO = 6 (2–14)	0	0	NR	1
Fagotti et al. [27]	2011	Prospective	2	BOT	NR	39.5 (18–115)	10 (5–150)	NR	0	0	1.3 ± 0.5	0
Kim et al. [28]	2011	Retrospective	6	Serous adenocarcinoma of the ovary (2), BOT (4)	NR	50.33 ± 13.26	42.83 ± 42.59	NR	6	2	1.94 ± 0.45	1
Boruta et al. [46]	2011	Retrospective	5	Endometrial cancer	Early	243 (197–289)	50 (25–100)	PL = 14 (10–33), p.ao. = 13 (7–20)	0	0	1 (1–2)	0

Fagotti et al. [29]	2011	Prospective, case control	3	BOT	NR	38.5 (20–115)	20 (10–150)	NR	2	1	1 (1–2)	2
Fanfani et al. [47]	2012	Prospective	20	Endometrial cancer	IA G1	105 (85–185)	20 (10–180)	NR	0	0	1 (1–2)	0
Escobar et al. [48]	2012	Retrospective cohort study	30	Endometrial cancer	I–II	155 (56–210)	100 (70–200)	PL = 16 (11–21) PAO = 11 (1–12)	1	0	1.2 (0–3)	1
Takeda et al. [43]	2012	Retrospective	2	Adnexal tumors	NR	72 (35–153)	10 (10–690)	NR	0	3	4 (3–19)	NR
Fanfani et al. [41]	2012	Retrospective cohort study	16	Endometrial cancer, in situ cervical cancer	Early endometrial cancer	105 (75–125)	30 (10–80)	NR	1	0	1 (1–3)	1
Fagotti et al. [49]	2012	Retrospective, comparative	75	Endometrial cancer	IA (67), IB (5), II (2), IIIC1 (1)	122 (45–220)	50 (10–500)	PL = 17 (10–20)	3	3	1 (1–4)	3
Fagotti et al. [50]	2012	Retrospective	100	Endometrial cancer	I (94), II (3), III (3)	129 (45–321)	70 (10–500)	PL = 16 (1–33) PAO = 7 (2–28)	4	4	1 (1–4)	2
Fanfani et al. [33]	2013	Prospective, comparative	17	Endometrial cancer, in situ cervical cancer	Early stage endometrial cancer	120 (55–165)	30 (10–300)	NR	0	0	2 (1–5)	2
Fagotti et al. [51]	2013	Retrospective case control	38	Endometrial cancer	I (37), II (1)	107 (4–140)	30 (10–300)	NR	0	0	NR	0
Boruta et al. [52]	2013	Retrospective	22	Cervical cancer	IA1–IB1	260	60	PL = 22 (4–34)	1	2	1	2

OT operative time, *EBL* estimated blood loss, *pl* pelvic lymphnodes, *p.ao.* para-aortic lymph nodes, *BOT* borderline ovarian tumor, *CV* conversion, *NR* not reported

(50 ml) and hospital stay (1 day). No intraoperative and postoperative complication occurred and no patients required conversion to laparotomy and conventional laparoscopy. Another study [47], including at least 20 cases of endometrial cancer, aimed at evaluating the safety, feasibility, and surgical outcomes of single-site hysterectomy in a consecutive endometrial cancer stage IA series. The procedures were performed without conversion and intraoperative or postoperative complication; the blood loss was 20 ml, while the operative time was 105 min, trending to decrease after almost ten procedures. Cosmetic results and postoperative controls were both satisfactory. Following studies included a greater number of cases of endometrial cancer, confirming the results already highlighted. Fagotti et al. [50] reported their findings about the first 100 early endometrial cancer cases treated with LESS. In all the 100 cases, total hysterectomy and bilateral salpingo-oophorectomy were performed, while pelvic and para-aortic lymphadenectomy in 48 and 27 patients, respectively. The median numbers of pelvic and para-aortic lymph nodes were 16 and 7, respectively, similar to those reported in studies utilizing traditional laparoscopy. Two patients, undergone lymphadenectomy, required conversion, and four intraoperative and four postoperative complications overall occurred. Altogether, LESS achieved good results in terms of surgical outcomes, postoperative pain, and cosmesis. Since the important role of the minimally invasive surgery in gynecological surgery, several studies have compared perioperative outcomes of different minimally invasive techniques. An Escobar report [48] compared LESS and conventional laparoscopic and robotic surgery in the treatment of endometrial cancer, but no differences were found in terms of operative time, blood loss, hospital stay, and complication rates. Subsequently, another study compared LESS and robotic surgery [49], showing that LESS had a shorter operative time (122 ml vs 175 ml) and lower blood loss (50 ml vs 80 ml) than robotic surgery. Furthermore, a case-control study [51] compared LESS (38 patients) and robotic single-port surgery (19 patients), showing no clinical relevant differences. In 2012, two case studies by Fanfani et al. [33, 41], including cases with malignant disease, compared LESS and mini-laparoscopic surgery. No significative differences were found in terms of surgical outcomes except for operative time that was longer in LESS groups. At the same time, mini-laparoscopic surgery was associated to a less postoperative pain. Some studies [14, 16, 23, 27–29, 43, 45] have reported data about the use of LESS in the treatment of adnexal malignant disease, showing good surgical outcomes. However, in this study, the number of patients treated for malignant ovarian cancer was too small to draw conclusions about. LESS has been applied also in risk-reducing salpingo-oophorectomy [44], resulting in excellent surgical and cosmetic outcomes. Furthermore, Escobar in 2010 [45] described the single-port laparoscopic pelvic and para-aortic lymphadenectomy in 21 patients. The median numbers of pelvic and para-aortic lymph nodes retrieved were 14 and 6, respectively, and all procedures were successfully completed with only 1 conversion to traditional laparoscopy. Actually, few studies report data about LESS in cervical cancer [52, 53]. Recently, a case report [53] has described how the LESS radical hysterectomy type III in stage Ib1 cervical cancer could be successfully performed.

13.6 Our Experience

Between July 2009 and June 2013 (Tables 13.3 and 13.4), 47 woman underwent LESS hysterectomy for the treatment of early stage endometrial cancer at the Gynecological Oncological Unit, National Cancer Institute, Regina Elena, Rome, Italy.

All patients were positioned in the dorsal lithotomic Trendelenburg position, with both legs supported by straps. Using the Hasson technique, it was possible to place the SILS port (Covidien) through a 1.8–3 cm umbilical incision. The SILS port (Covidien) is a multichannel port that allows the insertion of up to three instruments. After the insufflation of CO_2 through one of the three available channels, it was possible to introduce a 5 mm trocar for the insertion of the 30° laparoscope. In the remaining two channels, two 5 mm trocars were placed for the introduction of additional instruments. All patients underwent type A hysterectomy plus salpingo-oophorectomy (Querleu-Morrow classification) [54]. After cauterization of the fallopian tubes, the right round ligament was sectioned, entering in the retroperitoneal space. Then, the ureter and uterine artery were visualized and adnexal resection was

Table 13.3 Clinical characteristics of the 47 women with endometrial cancer operated by LESS type A hysterectomy

Characteristics	Patients ($n = 47$)
Median age	45 (39–84)
Median BMI (kg/m^2)	21.8 (19–48)
Previous abdominal surgery (%)	29.7
Histology	
Adenocarcinoma	46
Clear cell	1
FIGO stage	
IA	32
IB	11
II	3
III	1

BMI body mass index

Table 13.4 Surgical outcome of patients with endometrial cancer operated by LESS type A hysterectomy

Characteristics	Patients ($n = 47$)
Median skin and fascial incision (cm)	2.2 (2.0–2.5)
Median time positioning port (min)	1.5 (1–3)
Median operative time (min)	100 (50–240)
Median blood loss (ml)	90 (10–300)
Major intraoperative complications	0
Major postoperative complications	4
Blood transfusion	0
Conversion to laparoscopy	2
Reoperation	0
Median hospital stay (day)	3 (2–9)
Median follow-up (month)	27 (4–50)
Recurrence	0

performed. Subsequently, at first, the vesicouterine and the vesicovaginal spaces were developed, and then, the rectovaginal space was developed incising the posterior part of peritoneum. In this way, it was possible to cauterize the uterine vessels. Finally, a sufficiently wide margin of vagina was exposed allowing the section. In the end, uterus and adnexa were extracted through the vagina and the vaginal cuff has been closed laparoscopically or through the vagina. No lymph node dissection was performed in the low-risk endometrial cancer cases. Pelvic and para-aortic lymphadenectomies were performed only in six and one cases, respectively, and the median numbers of lymph nodes retrieved were 13.5 and 4, respectively. Median age was 45 and median BMI was 21.8. Forty-three patients were in stage I, of which 32 in stage IA and 11 in stage IB, 3 patients were in stage II, and 1 patient was in stage IIIA. No intraoperative complication occurred, but there were four postoperative complications: a vaginal cuff dehiscence, an umbilical wound infection, a lymphorrhea, and a bladder fistula in the same patient during the 13th day. All procedures were completed successfully, but there were two patients who required a laparoscopic conversion due to extensive adhesions from previous surgery. Median operative time was 100 min, median blood loss was 90 ml, and median hospital stay was 3 days. The median follow-up was 27 month and only one patient died due to the occurrence of a new cancer after 11 month from the surgery.

13.7 Challenges of LESS

LESS is widely applied in the gynecological surgery with the same absolute contraindication of the conventional laparoscopy: a metastatic disease, heart or pulmonary disease, and severe abdominal adhesions. Moreover, the surgeon should have advanced skills in laparoscopic and single-port surgery. Obesity and previous abdominal surgery should no longer be considered absolute limits in the performance of LESS. One of the most important technical challenges is the instrument crowding due to the restricted space available to perform movements. This problem can be overcome crossing the instruments or utilizing the Gel point. As a matter of fact, this device allows placing the instruments in the desired angulations. The lack of triangulation is another important problem that can be easily overcome applying articulating and flexible instruments or curved instruments. However, an extensive experience in laparoscopy might be enough to overcome the challenges in single-port surgery. The latest innovation in minimally invasive surgery is the introduction of the robotic system da Vinci [55]. The combination of robot and single port gives new advantages and it allows the overcoming of many challenges in single-port surgery. As a matter of fact, despite being an expensive surgical technique, robotic surgery improves the triangulation of instruments and surgical outcomes, and, moreover, it has a shorter learning curve. Probably, the robotic single port could be a promising new surgical approach also in morbidly obese woman. In a recent study [56], robotic surgery was confirmed to be the best surgical approach in the treatment of endometrial cancer in obese woman. This would mean that the application of the da Vinci robotic system in gynecological surgery might make the single-site surgery feasible and safe also in morbidly obese woman.

Conclusions

Laparoendoscopic single-site surgery is a safe and feasible surgical approach in the treatment of both benign and malignant gynecological disease. Moreover, LESS improves surgical outcome and cosmetic results and reduces postoperative pain. Further studies are needed to define the long-term outcomes and, in gynecological oncology, the disease-free survival and overall survival. Robotic single-port surgery is a potential area of development, but it still is not completely clear if the benefits of robotic surgery might justify the high costs of this new approach.

References

1. Walker JL, Piedmonte MR, Spirtos NM et al (2009) Laparoscopy compared with laparotomy for comprehensive surgical staging of uterine cancer: Gynecologic Oncology Group Study LAP2. J Clin Oncol 27:5331–5336
2. Gill IS, Advincula AP, Aron M et al (2010) Consensus statement of the consortium for laparoendoscopic single-site surgery. Surg Endosc 24:762–768
3. Escobar PF, Starks D, Fader NA et al (2010) Laparoendoscopic single-site and natural orifice surgery in gynecology. Fertil Steril 94:2497–2502
4. Wheeless C (1969) A rapid, inexpensive, and effective method of surgical sterilization by laparoscopy. J Reprod Med 5:255
5. Pelosi MA, Pelosi MA (1992) Laparoscopic supracervical hysterectomy using a single-umbilical puncture (mini-laparoscopy). J Reprod Med 37:777–784
6. Kommu SS, Kaouk JH, Rane A et al (2009) Laparoendoscopic single-site surgery: preliminary advances in renal surgery. BJU Int 103:1034–1037
7. Canes D, Berger A, Aron M et al (2010) Laparo-endoscopic single site (LESS) versus standard laparoscopic left donor nephrectomy: matched-pair comparison. Eur Urol 57:95–101
8. Sesia SB, Frech M, Hacker FM, Mayr J et al (2010) Laparoscopic “single-port” appendectomy in children. Zentralbl Chir 136(1):50–55
9. Langwieler TE, Nimmesgern T, Back M et al (2009) Single-port access in laparoscopic cholecystectomy. Surg Endosc 23:1138–1141
10. Choi S, Lee K, Park S, Lee S-H et al (2010) Single port laparoscopic right hemicolectomy with D3 dissection for advanced colon cancer. World J Gastroenterol 16:275–278
11. Bedaiwy MA, Escobar PF, Pinkerton J et al (2011) Laparoendoscopic single-site salpingectomy in isthmic and ampullary ectopic pregnancy: preliminary report and technique. J Minim Invasive Gynecol 18:230–233
12. Yoon BS, Park H, Seong SJ et al (2010) Single-port laparoscopic salpingectomy for the surgical treatment of ectopic pregnancy. J Minim Invasive Gynecol 17:26–29
13. Lim MC, Kim TJ, Kang S et al (2009) Embryonic natural orifice transumbilical endoscopic surgery(E-NOTES) for adnexal tumors. Surg Endosc 23:2445–2449
14. Kim TJ, Lee YY, Kim MJ et al (2009) Single port access laparoscopic adnexal surgery. J Minim Invasive Gynecol 16:612–615
15. Lee YY, Kim TJ, Kim CJ et al (2009) Single-port access laparoscopic-assisted vaginal hysterectomy: a novel method with a wound retractor and a glove. J Minim Invasive Gynecol 16:450–453
16. Fader AN, Escobar PF (2009) Laparoendoscopic single-site surgery (LESS) in gynecologic oncology: technique and initial report. Gynecol Oncol 114:157–161
17. Lee YY, Kim TJ, Kim CJ et al (2010) Single port access laparoscopic adnexal surgery versus conventional laparoscopic adnexal surgery: a comparison of peri-operative outcomes. Eur J Obstet Gynecol Reprod Biol 151:181–184

18. Kim TJ, Lee YY, Cha HH et al (2010) Single-port-access laparoscopic-assisted vaginal hysterectomy versus conventional laparoscopic-assisted vaginal hysterectomy: a comparison of perioperative outcomes. Surg Endosc 24:2248–2252
19. Yim GW, Jung YW, Paek J et al (2010) Transumbilical single-port access versus conventional total laparoscopic hysterectomy: surgical outcomes. Am J Obstet Gynecol 203:26e1–26e6
20. Lee M, Yim GW (2011) A randomized prospective study of single-port and four-port approaches for hysterectomy in terms of postoperative pain. Surg Endosc 25(8):2462–2469
21. Kim YW, Park BJ, Ro DY et al (2010) Single-port laparoscopic myomectomy using a new single-port transumbilical morcellation system: initial clinical study. J Minim Invasive Gynecol 17:587–592
22. Escobar PF, Bedaiwy MA, Fader AN et al (2010) Laparoendoscopic single-site (LESS) surgery in patients with benign adnexal disease. Fertil Steril 93:2074e7–2074e10
23. Fader AN, Rojas-Espaillate IO, Grumbine FC et al (2010) Laparoendoscopic single-site surgery (LESS) in gynecology: a multi-institutional evaluation. Am J Obstet Gynecol 203: 501e1–501e6
24. Song T, Kim TJ, Kim MK et al (2010) Single port access laparoscopic assisted vaginal hysterectomy for large uterus weighing exceeding 500 grams: technique and initial report. J Minim Invasive Gynecol 17:456–460
25. Yoon G, Kim TJ, Lee YY et al (2010) Single-port access subtotal hysterectomy with transcervical morcellation: a pilot study. J Minim Invasive Gynecol 17:78–81
26. Paek J, Kim SW, Lee SH et al (2011) Learning curve and surgical outcome for single-port access total laparoscopic hysterectomy in 100 consecutive cases. Gynecol Obstet Invest 72:227–233
27. Fagotti A, Fanfani F, Marocco F et al (2011) Laparoendoscopic single site surgery for the treatment of benign adnexal diseases: a pilot study. Surg Endosc 25:1215–1221
28. Kim WC, Lee JE, Kwon YS et al (2011) Laparoendoscopic single-site surgery (LESS) for adnexal tumors: one surgeon's initial experience over a one-year period. Eur J Obstet Gynecol Reprod Biol 158:265–268
29. Fagotti A, Rossitto C, Marocco F et al (2011) Perioperative outcomes of laparoendoscopic single-site surgery (LESS) versus conventional laparoscopy for adnexal disease: a case-control study. Surg Innov 18:29–33
30. Yoon BS, Park H, Seong SJ et al (2011) Single-port versus conventional laparoscopic salpingectomy in tubal pregnancy: a comparison of surgical outcomes. Eur J Obstet Gynecol Reprod Biol 159:190–193
31. Chen YJ, Wang PH, Ocampo EJ et al (2011) Single-port compared with conventional laparoscopic-assisted vaginal hysterectomy: a randomized controlled trial. Obstet Gynecol 117:906–912
32. Fagotti A et al (2011) Postoperative pain after conventional laparoscopy and laparoendoscopic single site surgery (LESS) for benign adnexal disease: a randomized trial. Fertil Steril 96
33. Fanfani F, Fagotti A, Gagliardi L et al (2013) Minilaparoscopic versus single-port total hysterectomy: a randomized trial. JMIG 20:192–197
34. Hoyer-Sorensen C, Vistad I, Ballard K (2012) Is single-port laparoscopy for benign adnexal disease less painful than conventional laparoscopy? A single-center randomized controlled trial. Fertil Steril 98(4):973–979
35. Cho YJ, Kim ML, Lee SY et al (2012) Laparoendoscopic single-site surgery (LESS) versus conventional laparoscopic surgery for adnexal preservation: a randomized controlled study. Int J Womens Health 4:85–91
36. Han CM, Lee CL, Su H et al (2013) Single port laparoendoscopic myomectomy: initial operative experience and comparative outcome. Arch Gynecol Obstet 287:295–300
37. Kim YW, Park BJ, Kim TE et al (2013) Single-port laparoscopic salpingectomy for surgical treatment of tubal pregnancy: comparison with multi-port laparoscopic salpingectomy. Int J Med Sci 10(8):1073–1078
38. Yim GW, Lee M, Nam EJ et al (2013) Is single-painful than conventional laparoscopy for adnexal surgery? A comparison of postoperative pain and surgical outcomes. Surg Innov 20(1):46–54

39. Choi YS, Park JN, Oh YS et al (2013) Single-port vs. conventional multi-port access laparoscopy-assisted vaginal hysterectomy: comparison of surgical outcomes and complications. Eur J Obstet Reprod Biol 169:366–369
40. Yoo E, Shim E et al (2013) Single-port access compared with three-port laparoscopic adnexal surgery in a randomized controlled trial. J Int Med Res 41:673
41. Fanfani f, Fagotti A, Rossitto C et al (2012) Laparoscopic, minilaparoscopic and single-port hysterectomy: perioperative outcomes. Surg Endosc 26:3592–3596
42. Li M, Han Y, Feng Yc et al (2012) Single-port laparoscopic hysterectomy versus conventional laparoscopic hysterectomy: a prospective randomized trial. J Int Med Serc 40:701
43. Imoto S, Mori M et al (2013) Management of large adnexal tumors by isobaric laparoendoscopic single-site surgery with a wound retractor. Eur J Obstet Gynecol Reprod Biol 166:185–190
44. Escobar PF, Starks DC, Fader AN et al (2010) Single-port risk-reducing salpingo-oophorectomy with and without hysterectomy: surgical outcomes and learning curve analysis. Gynecol Oncol 119:43–47
45. Escobar PF, Fader AN, Rasool N et al (2010) Single-port laparoscopic pelvic and para-aortic lymph node sampling or lymphadenectomy: development of a technique and instrumentation. Int J Gynecol Cancer 20:1268–1273
46. Boruta DM, Growdon WB, Schorge JO et al (2011) Single-incision laparoscopic staging for endometrial cancer. J Am Coll Surg 212:e1–e5
47. Fanfani F, Rossitto C, Gagliardi ML et al (2012) Total laparoendoscopic single-site surgery (LESS) hysterectomy in low-risk early endometrial cancer: a pilot study. Surg Endosc 26:41–46
48. Escobar PF, Frumovitz M, Soliman PT et al (2012) Comparison of single-port laparoscopy, standard laparoscopy, and robotic surgery in patients with endometrial cancer. Ann Surg Oncol 19:1583–1588
49. Fagotti A, Gagliardi ML, Fanfani F et al (2012) Perioperative outcomes of total laparoendoscopic single-site hysterectomy versus total robotic hysterectomy in endometrial cancer patients: a multicentre study. Gynecol Oncol 125:552–555
50. Fagotti A, Boruta DM, Scambia G et al (2012) First 100 early endometrial cancer cases treated with laparoendoscopic single-site surgery. A multicentric retrospective study. AJOG 206:353.e1–353.e6
51. Fagotti A, Corrado G, Fanfani F et al (2013) Robotic single-site hysterectomy (RSS-H) vs. laparoendoscopic single-site hysterectomy (LESS-H) in early endometrial cancer: a double-institution case–control study. Gyencol Oncol 130:219–223
52. Boruta DM, Fagotti A, Bradford LS et al. (2013) Laparoendoscopic single-site radical hysterectomy with pelvic lymphadenectomy: initial multi-institutional experience for treatment of invasive cervical cancer. J Minim Invasive Gynecol.
53. Garret LA, Boruta DM (2013) Laparoendoscopic single-site radical hysterectomy. AJOG 207:518.e1
54. Querleu D, Morrow CP (2008) Classification of radical hysterectomy. Lancet Oncol 9: 297–303
55. Escobar PF, Fader AN, Paraiso MF et al (2009) Robotic-assisted laparoendoscopic single-site surgery in gynecology: initial report and technique. J Minim Invasive Gynecol 16:589–591
56. Gehrig PA, Cantrell La, Shafer A et al (2008) What is the optimal minimally invasive surgical procedure for endometrial cancer staging in obese and morbidly obese woman? Gynecol Oncol 111:41–45

Single-Access Robotic Surgery

14

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14.1 Robotics in Surgery

The volume of available clinical outcomes of robotic laparoendoscopic single-site surgery (R-LESS) has considerably grown since the pioneering description of the first successful clinical series of single-port robotic procedures. The feasibility of robot-assisted single-incision urologic and colorectal, as well as of many gynecologic, procedures has been demonstrated. A novel set of single-site instruments specifically dedicated to LESS is now commercially available for use with the da Vinci Si Surgical System, and both experimental and clinical uses have been reported. However, the current robotic systems were specifically designed for LESS. The ideal robotic platform should have a low external profile, the possibility of being deployed through a single-access site, and the possibility of restoring intra-abdominal triangulation while maintaining the maximum degree of freedom for precise maneuvers and strength for reliable traction.

The concept of laparoendoscopic single-site surgery is based on the minimization of skin incision to gain access to the abdominal or pelvic cavities to perform surgical procedures. This concept might translate into a benefit for patients in terms of port-related complications, recovery time, pain, and cosmesis [1–3]. Furthermore, muscle sparing (transumbilical approach) and restriction of trauma to a small area of the abdominal wall may explain these findings. Moreover, the single-site access might also reduce adhesiogenic surface.

Early comparative studies have suggested that LESS is at least comparable to standard laparoscopy [4, 5]. A large multi-institutional analysis has shown that

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G. Pignata et al. (eds.), *Single-Access Laparoscopic Surgery*,
DOI 10.1007/978-3-319-06929-6_14,

LESS has significantly evolved, becoming a widely applicable technique in a relatively short time [6]. Stringent patient selection criteria should be applied by surgeons approaching LESS to minimize the likelihood of complications [7]. Despite the increasing interest in LESS worldwide, the actual role of this novel approach in the field of minimally invasive surgery remains to be determined and its claimed advantages to be demonstrated. Some features of LESS represent significant challenges compared with standard laparoscopy. Novel systems have been tested to offer intuitive instrument maneuverability and restored triangulation without external instrument clashing, but their use remains experimental [8]. To overcome these constraints, it has been postulated that robotic technology could be applied to LESS [9–12]. In 2009, Kaouk et al. reported the first successful series of single-site robotic procedures in humans, and the authors noted improved facility for intracorporeal dissecting and suturing because of robotic instrument articulation and stability [13]. Since then, there has been a growing interest from investigators in different surgical specialties [14, 15].

14.2 Single-Site Robotic Surgery: Advantages and Limits

Laparoendoscopic single-site surgery (LESS) is a promising technique that might progressively substitute conventional laparoscopy (CL).

However, LESS remains difficult to perform because of technical difficulties such as loss of triangulation, poor exposition, and instrument crowding with conflicts of space on the patient's exterior and other issues. Therefore, this approach has been and is still under technical development. These technical difficulties lead to limited use by mainly experienced and skillful surgeons.

One major technical disadvantage in LESS is the "sword fighting" among instruments. During standard LESS, as laparoscopic instruments are inserted into the abdominal cavity through a single incision, there can be a tendency to cross them just below the abdominal wall to obtain a separation between instrument tips without external collision of the handpieces. This crossing of the instruments allows a better range of motion, but the resultant reversal of handedness introduces a major mental challenge for the surgeon. Nevertheless, with the development of bent instruments and new port devices, triangulation can be restored in proximity of the target.

As a way to facilitate LESS and to restore dexterity, some surgeons have moved forward and amalgamated this technique with robotic surgery.

This has led to a new kind of surgery, robotic LESS or R-LESS. In the early approaches to R-LESS, researchers used a combination of commercially available single-incision laparoscopy equipment and augmented it with robotic technology.

The da Vinci Surgical System was the first robotic system cleared by the US Food and Drug Administration for use in general and urologic laparoscopic surgery. Some of its benefits over conventional laparoscopy include superior ergonomics, optical magnification of the operative field, enhanced dexterity, and greater precision.

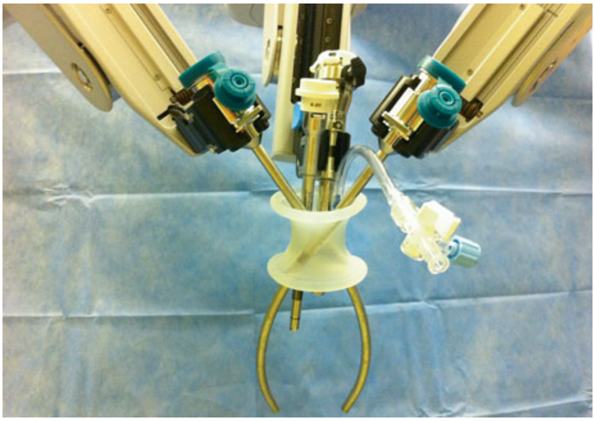

Fig. 14.1 The “Chopstick” surgery technique prevents the collision of the external robotic arms

To address limitations related to the coaxial arrangement of instruments, Joseph et al. [16, 17] defined a “chopstick” surgery technique enabling the use of the robotic arms through a single incision without collision (Fig. 14.1).

The robotic instruments cross at the abdominal wall to have the right instrument on the left side of the target and the left instrument on the right. To correct for the change in handedness, the robotic console was instructed to drive the left instrument with the right-hand effector and the right instrument with the left-hand effector. In this way, collision of the external robotic arms was prevented. A similar robotic setup was adopted by Hagen et al., who explored the feasibility of single-incision transabdominal and transvaginal surgery by crossing control-switching robotic arms to achieve an intuitive control. Allemann et al. compared the outcomes of LESS Nissen fundoplication performed with and without a robotic platform in a porcine model [18]. Sugimoto et al. performed eight robotic hepatobiliary LESS procedures, including four cholecystectomies and four lateral liver segmentectomies, in a porcine study [19]. Again, the instruments were crossed to avoid sword fighting and clashing of instruments.

Laparoscopic suturing and knot tying are considered advanced skills with a steep-learning curve. Although the multisite approach to laparoscopic surgery is the gold standard, increasingly complex operations are attempted with a minimal port approach. Suturing and intracorporeal knot tying with single-port systems pose significant difficulty, often requiring conversion to traditional multiport laparoscopy or even open surgery. In fact, while suturing with extracorporeal knot tying is described, few reports describe the learning curve of intracorporeal knot tying using LESS surgical techniques [20, 21]. A specialized robotic platform for single-site surgery can overcome the technical difficulties inherent to LESS surgery and to improve operator ergonomics [22, 23]. Furthermore, the robotic single-site platform would make more complex laparoscopic tasks easier than using more conventional single-incision laparoscopic surgical techniques.

14.3 Single-Port Devices for Robotic Surgery

As demonstrated by the high number of publications, R-LESS is a topic of interest. This is particularly true in the field of urology, general surgery, and gynecology. The analyses of the reviewed articles show that R-LESS is technically feasible and safe for patients.

Most of the publications recorded were clinical case series and only few comparative studies were found. At present, no clinical controlled study has been reported. However, the technique is new and we can expect in the future to have publications with higher levels of evidence. Nevertheless, we can hypothesize that R-LESS may share common outcomes with LESS which could be used as a surrogate. Another limitation of this review is that the reports covered a wide range of procedures in different surgical specialties (mainly urology, general surgery, and gynecology). Therefore, direct comparison was not always possible, but reviewing different approaches has identified technical difficulties and common solutions. It is evident from the literature that many access devices have been used so far for R-LESS.

14.3.1 TriPort®/QuadPort®

TriPort® is a multichannel port with three soft valves. In order to adapt the instruments and the camera, robotic ports are inserted directly in the valves of the multichannel port. Two of the three valves are used for one instrument and the camera. The third valve is left to the assistant for suction and retraction. A third robotic port for the second instrument is placed directly in the wound, in tandem with the R-port (hybrid port technique). Using a QuadPort®, Desai et al. [24] reported a similar method. However, they didn't place any robotic port beside the multichannel port. Both instruments and the camera passed through the four valves of the QuadPort®. However, this device requires a minimal 25-mm length incision, whereas the TriPort® needs only 12 mm. Allemann et al. [18] used only three valves of QuadPort® which was positioned supraumbilically and placed an accessory port in the right hypochondrium. Hagen et al. [23] inserted both the instruments and the laparoscope through one TriPort.

14.3.2 GelPort®

The GelPort is an Alexis wound retractor/protector (Applied Medical, Rancho Santa Margarita, CA, USA) adapted with a gel seal cap. The robotic ports were directly inserted in the gel. The device rapidly became widely used for R-LESS. Ragupathy et al. [25] reported their initial experience with GelPOINT®. This platform is a kind of GelPort designed especially for single-site surgery with insufflation and venting access.

14.3.3 SILS®

Following the several attempts to use robotic technology originally designed for multiport surgery by different authors, Intuitive Surgical International (Sunnyvale, CA, USA) has recently developed a new set of instruments and accessories for robotic single-incision laparoscopy to be used with the da Vinci Si Surgical System®: the da Vinci Single-Site Instrumentation.

Since the market introduction of this new instrumentation in March 2011 in Europe and December 2011 in the USA, an increasing number of surgeons have started the clinical use of the da Vinci® Single-Site Instrumentation for different procedures.

The set includes a multichannel access port with room for four cannulas and an insufflation valve. Two curved cannulas are for robotically controlled instruments, and the other two cannulas are straight; one cannula is 8.5 mm and accommodates the robotic endoscope, and the other cannula is a 5-mm bedside-assistant port. The curved cannulas are integral to the system, since their configuration allows the instruments to be positioned to achieve triangulation of the target anatomy. This triangulation is achieved by crossing the curved cannulas midway through the access port. Same-sided hand–eye control of the instruments is maintained through assignment of software of the Si system that enables the surgeon's right hand to control the screen right instrument even though the instrument is in the left robotic arm and, reciprocally, the left hand to control the screen left instrument even though the instrument is in the right robotic arm. The second part of the platform is a set of semirigid, nonwristed instruments with standard da Vinci® instrument tips. The semirigid, flexible shaft allows for insertion down the curved cannula and triangulation of the anatomy. Robotic arm collisions are minimized externally because the curved cannulas angle the robotic arms away from each other. Internal collisions with the camera are avoided because the camera is designed to be placed into the middle of the curved cannula zone and is not in a parallel arrangement. The single-site instruments and accessories are intended to be used with the da Vinci® Si Surgical System and are of similar construction to existing EndoWrist instruments, except they do not have a wrist at the distal end of the instrument.

These accessories are of great value as their multichannel port includes four separate access ports for instruments, camera, and assistance. They easily recreate triangulation and allow better visualization of the operating field.

14.3.4 Trocars and Surgical Setting

QuadPort offers enough access for instruments, laparoscope, and assistance, but the minimum incision required is large (25 mm). With only three channels, R-port/TriPort is smaller. Authors using QuadPort or TriPort reported numerous instrument conflicts. Moreover, the TriPort's outer ring is rigid and induced interference with the robotic port placed alongside. That's why Stein et al. [26] changed to GelPort. This configuration avoids almost all collisions. It allows enough space to be kept between each port. According to Joseph et al. [16], 2 cm is the minimum distance required between each port to avoid "sword fighting." Moreover, the GelPort allows resetting port placement during the operation. Another advantage of the GelPort is that it can be placed in various positions. For example, the Alexis wound retractor/protector can be partially folded so that the GelPort can lie on the edge on the abdomen [19]. This maneuver allows the instruments to have extreme angulation with the abdominal wall. However, the GelPort requires a large incision, which might be an advantage when large specimens need to be extracted (3–5 cm).

Because of its foam structure, the SILS Port seems to be very effective in maintaining pneumoperitoneum. However, it doesn't avoid instrument clashing and offers only three accesses. As a result, a supplementary port is generally required.

Regarding the arm positioning, the "chopstick" technique is a cornerstone. As demonstrated by many authors, it is helpful in reducing crowding and instrument clashing as well as allowing more lateral range of motion. Da Vinci S and SI have a thinner arm than the standard version. This means that they are less clumsy. In order to reduce external collisions, these versions should be used preferentially. Moreover, 5-mm instruments are thinner and more adapted to R-LESS because of their design. Indeed, they are not conventionally articulated and can deflect. Their range of motion is thus more important than a classical EndoWrist instrument. Changing the level of motion scaling is another option to reduce instrument clashing. When the robot is adjusted for fine-tuning, it slows down the movements realized by the arms. Most tested surgeries needed assistance for retraction, irrigation, suction, etc. Some procedures required specific implements like a stapler, bulldog clamps, or a LigaSure®. An assistant port frequently necessitates a second access through the same wound (hybrid port) or in another place (dual-port technique).

In these cases, the technique does not formally meet the criteria of single-site surgery. Owing to technical difficulty, a second port is particularly necessary for some procedures like partial nephrectomies [27]. Nevertheless, the introduction of a third instrument complicates the position that the robotic arms need to keep to avoid collisions. Use of bariatric instruments allows the assistant to interfere less with the robot [28]. When possible, it is easier to work without any ancillary port. The marionette technique or needlescopic retractors seem to be valid options for dynamic retraction. Most surgeons use an assistant for dynamic retraction either through an assistant port or through the techniques described above. The EndoGrab system permits static retraction. It is easy to use and provides good retraction without breaching the abdomen. Of course, it is not possible to modify exposition without resetting the device placement.

14.4 Single-Port Robotic Surgery: Current Clinical Applications

Desai et al. [24] were the first to report an R-LESS experiment conducted in 2008 on a cadaveric model. The procedure was a transvesical radical prostatectomy. At the same time, Kaouk et al. [13] published the first R-LESS clinical case report. The authors performed three different kinds of urologic procedures: an intraperitoneal radical prostatectomy, a pyeloplasty, and a radical nephrectomy. The same group also reported the first human R-LESS partial nephrectomy in a further publication [29]. At the beginning of 2009, Barret et al. [22] from French Institut Montsouris reported initial clinical experiences with R-LESS extraperitoneal radical prostatectomy. The first R-LESS clinical case in gynecology was described by Escobar et al. [30]. They realized a prophylactic bilateral hysterosalpingo-oophorectomy for a patient with a history of familial breast cancer (BRCA). They subsequently reported two bilateral hysterosalpingo-oophorectomies and two bilateral salpingo-oophorectomies [31]. In July 2009, White et al. [32] mentioned the first and sole cases of R-LESS ureteral reimplant and sacral colpopexy. Ostrowitz et al. [21] were the first authors to report the use of R-LESS in digestive surgery. They performed right hemicolectomies for two villous tumors of the cecum and one ascendo-cecal adenocarcinoma. Romanelli et al. [33] mentioned the first R-LESS cholecystectomy. They used three separated fascia access in the same wound, but because of loss of pneumoperitoneum, the technique was abandoned and the procedure completed with LESS. Allemann et al. [18] performed Nissen fundoplication on 18 pigs with either R-LESS or LESS. They recorded external but also internal clashing by the means of an observer and a second laparoscope inserted in the left iliac fossa for this purpose. A unique case of partial colectomy for malignancy was performed by Ragupathy et al. [25].

Haber et al. [34] reported their initial wet laboratory experience with the da Vinci Single-Site Instrumentation in October 2010. Using a cadaveric model, Escobar et al. [35] performed the first modified radical hysterectomy with this device. Wren and Curet [28] and Kroh et al. [36] in the USA and Morel et al. [37] in Europe performed the first human cholecystectomies by means of Intuitive's new platform. The first case control survey was published by White et al. [38]. They matched 10 R-LESS radical nephrectomies with ten CL controls. Sugimoto et al. [19] published their experiences with R-LESS hepatic surgery. They performed four lateral segmentectomies on laboratory pigs. The first multicentric study was published in June 2011 and analyzes retrospectively registries' raw data.

Even if a wide range of surgical operations have been performed with the single-site robotic technology, only few operations have shown to have those features needed to be part of clinical routine.

14.4.1 Experience in Urologic Surgery

The volume of available clinical outcomes of robotic LESS (R-LESS) has considerably grown since the pioneering description of the first successful clinical series of single-port robotic procedures [13]. So far, roughly 150 robotic urologic LESS cases have been reported by different institutions across the globe, with a variety of techniques and port configurations.

14.4.1.1 Upper Urinary Tract Surgery

Further expanding the application of robotics to LESS, Kaouk and Goel [29] reported an initial experience with partial nephrectomy in two patients. Pediatric instruments, including graspers, electrocautery hook, and harmonic scalpel, were used for tumor exposure and excision. A 30° robotic lens was placed in the upward configuration. A 2.8-cm left lower pole anterior medial tumor and a 1.1-cm right lateral lower pole tumor were excised without renal hilar clamping. Both patients had confirmed renal cell carcinoma with negative margins, and there were no intra-operative complications. In another study from the Cleveland Clinic, Stein et al. [26] reported R-LESS using a GelPort as the access platform. Four procedures were successfully performed, including two pyeloplasties, one radical nephrectomy, and one partial nephrectomy. The GelPort provided adequate spacing and flexibility of port placement as well as acceptable access to the surgical field for the assistant. Nephrectomy—simple, radical, or living donor—is one of the most commonly performed procedures in the field of LESS, and different groups have reported their techniques and early comparative outcomes [39–41]. White et al. detailed the technique of R-LESS radical nephrectomy and reported the outcomes compared with the current gold standard laparoscopic procedure [38]. Two single-port devices, the SILS Port and the GelPort/GelPoint, were used equally, and the da Vinci S or Si Surgical System in a three-arm approach was used. There was no difference between R-LESS and conventional laparoscopy in terms of operative time, estimated blood loss, visual analogue scale, or complication rate. The R-LESS group had a lower median narcotic requirement during hospital admission and a shorter length of stay. Study limitations included the small sample size, short follow-up period, and retrospective study design.

LESS adrenal surgery has been effectively performed for a number of indications using a wide variety of approaches. Park et al. were the first to report a case of retroperitoneoscopic R-LESS adrenalectomy for an adrenal cortical adenoma [42]. A 3-cm transverse skin incision was made just below the lowest tip of the 12th rib, and after exposing the retroperitoneal space, a glove port was applied to the skin incision. A 10-mm robotic camera with a 30° up view and three 5-mm robotic ports were inserted through the glove port. The total operation time was 188 min, and the patient recovered uneventfully. LESS pyeloplasty is technically demanding, largely because of the difficulty associated with intracorporeal suturing through a single abdominal incision. By adopting the principle of the chopstick technique for R-LESS, Olweny et al. used a setup including a GelPoint access device, a 30° up robotic scope, and the da Vinci Si surgical robot to enhance the applicability of the robotic platform to LESS pyeloplasty and reduce its learning curve. The authors compared their initial ten cases of R-LESS pyeloplasty with the last ten cases of conventional LESS pyeloplasty done by a single surgeon. Mean operative time was significantly longer for R-LESS but was probably related to the stent insertion time. Two conversions to standard laparoscopy and two postoperative complications occurred in 30 % of LESS patients, whereas there were no conversions and one postoperative complication in the R-LESS group.

14.4.1.2 Pelvic Urologic Surgery

When first reporting an initial feasibility study of LESS radical prostatectomy in humans, Kaouk et al. acknowledged the limitation of this procedure because of challenges related to ergonomics and intracorporeal suturing, and they claimed a potential application of robotics [43]. Within the first clinical series of R-LESS from the same group, a case of radical prostatectomy was reported, and the benefits of the robotic platform were soon noticed [13]. After a preliminary experience in a cadaver model and a case completed with an additional 5-mm port [44], Barret et al. also reported a complete case of R-LESS radical prostatectomy. They used a single umbilical incision and placed a 12-mm port for the robotic scope, a 5-mm port for the assistant, and two 8-mm ports for the robotic arms arranged in a rhomboid fashion. Significant external robotic arm collisions were experienced, as well as a reduced space for the assistant to work [45]. White et al. detailed the surgical technique and reported the outcomes of 20 R-LESS radical prostatectomies [46]. Most of the study population was represented by low-/intermediate-risk patients with baseline erectile dysfunction. An incision of 3.0–4.5 cm was created intraumbilically. The initial robotic 8-mm port was placed at the most caudal portion of the incision on the right side and directed as far laterally as possible; this procedure was repeated on the opposite side with a 5-mm pediatric or standard 8-mm robotic port. A SILS Port was inserted and the patient placed in a steep Trendelenburg position. The da Vinci S or Si System in a three-arm approach was docked, and the robotic 12-mm scope introduced through the SILS Port, with a 5-mm channel free for the suction or sutures to be passed. Steps of the procedures resembled those of the standard robotic procedure. During the bladder neck dissection, a suture was placed through the abdominal wall and then through the distal bladder neck or prostatic base; it was then exited out of the abdominal wall to serve as a retractor in a "marionette" fashion. Prostatic dissection was obtained using a 5-mm harmonic scalpel in a non-nerve-sparing procedure. Otherwise, an interfascial nerve-sparing approach was accomplished with a combination of sharp dissection and robotically applied Hem-o-Lok clips. A standard lymph node dissection was performed, and vesicourethral anastomosis was done with two sutures in a semicircular running fashion. A positive margin was found in four cases, two of the margins in the first three cases. The limited follow-up did not allow a reliable oncologic assessment. Within the field of prostate surgery, single-port transvesical enucleation of the prostate (STEP) was demonstrated to be technically feasible but still challenging by Desai et al. [47]. Recently, Fareed et al. reported the perioperative and short-term outcomes of their initial series of robotic STEP [48]. Nine patients with symptomatic benign prostatic hyperplasia were scheduled for the procedure. A 3-cm lower midline incision was made, a cystotomy created, and a GelPort positioned in the bladder. The da Vinci Si operating system was docked. There was significant postoperative improvement in the flow rates, but a high-grade complication was observed in three patients (37.5 %). The authors concluded that despite providing adequate relief of bladder outlet obstruction, the procedure carries a high risk of complications, and its role remains to be determined.

14.4.2 Gynecologic Surgery

The introduction of single-site robotic surgery in gynecology is a recent event. The first worldwide case of robotically assisted single-port hysterectomy was performed by Cela et al. in 2011 [49]. From these experiences, few studies with limited case series or case reports were reported in literature regarding principally the single-site robotic hysterectomy [50–53].

14.4.2.1 Surgical Indication to Single-Site Surgery

On the basis of the limited experience reported in literature, nowadays, the indication for robotic single-site surgery in gynecology is not well standardized. However, single-site surgery permits to perform a series of procedures such as adnexectomy, hysterectomy, ovarian cystectomy, and peritoneal biopsy for endometriosis. In general, robotic single-site procedures are possible in benign or precancerous gynecologic disease, such as myoma, adenomyosis, cervical dysplasia, and endometrial hyperplasia, or in gynecology oncology, as endometrial cancer or cervical cancer in early stage. The inclusion criteria to single-site procedure are the absence of any contraindication to endoscopic surgery, the uterine size lesser than 16 gestational weeks, and absence of previous pelvic or abdominal radiation.

Bogliolo et al. have recently proposed that the sexual exchange in female to male transsexualism means a good indication to single-site robotic hysterectomy. The minimal invasive surgery performs an important choice in transsexualism; indeed, the reduction of aesthetic damage plays a key role in psychical acceptance. However, the standard laparoscopic or robotic hysterectomy required three pelvic accesses in abdominal wall, which can represent a specific marker of gynecologic surgical approach, with possible psychological trauma [52].

14.4.2.2 Surgical Technique

The single-site system is the same described by Cela et al. [49]. A specific multichannel not-reusable port is employed, with space for four cannulas and an insufflation valve. A target anatomy arrow indicator is also marked. The specific cannulas are the following: two 250 mm in length curved cannulas for robotic instruments, one cannula for the high-definition three-dimensional endoscope, and one 5- or 10-mm bedside-assistant surgeon cannula.

The positioning of surgical device is as follows: after the completed eversion of the umbilical scar with two Kocher surgical clamps, a 2-cm umbilical skin incision at the umbilicus midline in correspondence to the physiological hernia was performed. Indeed at the deepest point of umbilical scar, all the layers of abdominal wall merge, and the incision at this site allows a rapid opening. Through a 2-cm transumbilical incision, we introduce in the abdomen cavity the single-site port, grasped just above the lower rim using an atraumatic clamp, with a descending movement within the incision. The single-site port lubrification with a sterile saline solution previous the introduction is recommended. After the device positioning, the pneumoperitoneum up to 12 mmHg of pressure was started.

The patient was placed in lithotomic position at the 30° Trendelenburg position and the da Vinci Si robotic column was positioned between the patient's legs. Therefore, the robotic arms were opened in the opposite positions. A da Vinci Si 8.5-mm 30° endoscope was placed into the umbilical trocar. A watchful inspection of total peritoneal cavity was completed in order to discover any peritoneal lesion that represents exclusion criteria to the robotic single-site procedure.

Following, a 5×250-mm curved cannula (arm 2) was introduced through the specific lumen, under constant visualization of the cannula tip by the camera.

The cannula was located in front of the uterus and then held still to allow docking. The same process was performed for the placement of arm 1. Finally, the specific robotic instruments were introduced: a surgical forceps on arm 2 and a curved scissor on arm 1. The assistant's 5- or 10-mm cannula was also inserted. The absence of specific robotic bipolar instruments was overcome by the use of classic bipolar instruments, through the assistant's cannula. A second assistant placed the uterine manipulator in situ: this is a very important procedure because the uterine manipulation permits to supply the defect in lateral movement of single-site procedure.

14.4.2.3 Limits of the Technique

The principal technical limitation to single-site robotic procedure is the reduction in laterality movement and the difficulty in horizontal suture as vaginal cuff suture [49, 53]. The limitation in laterality is overcome by the use of the uterine manipulator, with the aid of a second assistant.

Vaginal cuff closure with intracorporeal suture represents an important limitation of single-site procedure as reported by all authors [49–53]. This restriction depends from the defect in rotation of the robotic single site dedicated instruments.

Therefore, we usually perform vaginal cuff closure transvaginally, which shows a safe technique according to the literature [54]. However, in selected cases, when the vaginal access appeared difficult, the use of extracorporeal suture with knot-push device allowed to overcome some limitations of the intracorporeal suture [53].

14.4.3 Current Application in General Surgery: Cholecystectomy

Cholecystectomy has been the most widely used application of LESS within general surgery. In 2011, two groups independently reported the first clinical experience with the novel da Vinci Single-Site platform. Kroh et al. from the Cleveland Clinic successfully performed 13 consecutive cholecystectomy operations [36]. One patient required placement of an additional extraumbilical trocar for appropriate visualization secondary to gallbladder necrosis, and this incision also was used for eventual drain placement. No significant complications occurred. Wren and Curet reported their outcomes in the first ten cases and compared them with the outcomes of traditional multiport laparoscopic cholecystectomy [28]. Another comparative study was reported by Spinoglio et al., who analyzed the data on the first 25 patients who underwent single-site robotic cholecystectomies and compared those data with their first 25 single-incision laparoscopic cholecystectomies [55].

Interestingly, the operative time was significantly longer for the single-incision laparoscopic cholecystectomies. Operating time decreased with increasing number of single-incision laparoscopic procedures; however, operative times for robotic single-site procedures were lower since the beginning, without major fluctuations, thus suggesting the robotic technique to be more intuitive and not to require a specific learning curve. Another early series was published by Morel et al., who described 28 cases successfully performed without conversions or complications [37]. Konstantinidis et al. reported a large experience with the da Vinci Single-Site cholecystectomy [56]. Forty-five patients underwent surgery without conversions, although in three cases, a second trocar was used. There were no major complications apart from a single case of postoperative hemorrhage. Intraoperative blood loss was negligible. The authors stressed the importance of specific training for the induction of pneumoperitoneum and the new port insertion and docking process.

Pietrabissa et al. recently [57] published the results of a prospective longitudinal observational study conducted on the first 100 da Vinci Single-Site cholecystectomies performed at five Italian centers of robotic surgery. They observed a 2 % conversion rate with a 12 % incidence of minor intraoperative complication (7 % incidence of bile spillage from the gallbladder and 5 % of minor bleeding from the liver bed) and the absence of major complications. These results are comparable with the results of most published series of SILS cholecystectomies.

14.4.3.1 Surgical Technique

The setups of the console and slave are similar to that for standard robotic surgery, and only arms 1 and 2 are used for this procedure. The da Vinci Single-Site instruments are similar to those of the existing da Vinci Si EndoWrist except that the entire length of the instruments is semirigid, allowing them to be inserted through the curved cannulas. These instruments do not have the wrist at the tip of the instrument, in contrast to standard robotic instrumentation. The instruments currently available for this platform includes needle drivers, Cadiere grasper, Maryland dissector, hook with cautery, curved shears, clip applier, and suction irrigation device. In addition to the curved robotic instruments, the trocar allows insertion of a 5-mm laparoscopic assistant instrument and a standard robotic three-dimensional 8.5-mm high-definition laparoscope. The trocar is designed to fit through a single fascial incision.

All laparoscopic cholecystectomy procedures are initiated as a single-incision, single-trocar technique. After standard preparation, a 20- to 25-mm vertical intraumbilical incision is fashioned, and dissection is carried down to the fascia. Entrance into the peritoneal cavity is performed under direct vision using a Hasson technique, and the fascial incision is enlarged to approximately 25 mm (Fig. 14.2).

After successful docking, the gallbladder fundus is identified, grasped, and retracted cephalad toward the patient's right shoulder. This then is given to the bedside assistant, and the surgeon transfers to the console. The instrument orientation is confirmed at the console such that the left hand of the surgeon at the console controlled the left instrument in the operative field despite the curved cannulas making an opposite configuration.

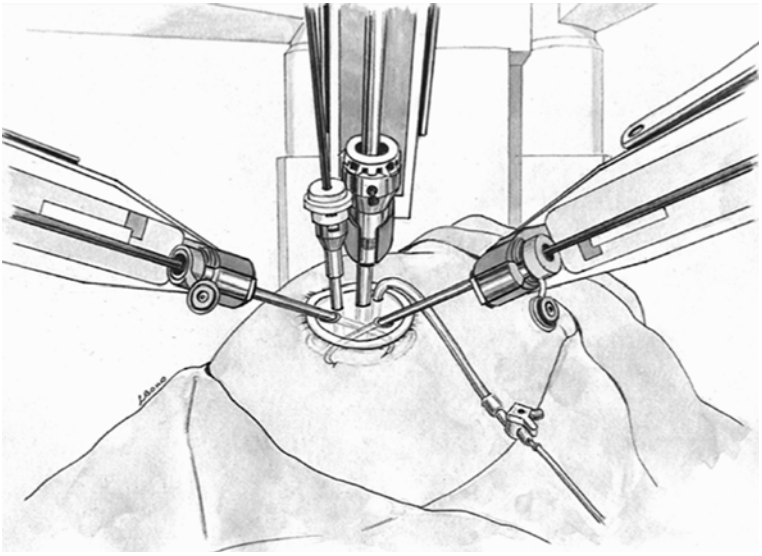

Fig. 14.2 Robotic arms setting in single-site cholecystectomy

Many studies have demonstrated early experience with this technique. Vidal et al. [58] reported a comparative study of 19 single-incision cholecystectomies and 19 traditional laparoscopic cholecystectomies. The results showed that all procedures were completed successfully and that the average operation time of the two groups was in the same range, indicating the feasibility and safety of performing single-incision cholecystectomy. Hodgett et al. [59] compared a cohort of 29 single-incision cholecystectomies with a cohort of 29 multi-incision laparoscopic cholecystectomies. The authors concluded that single-incision cholecystectomy was a safe and effective alternative to multi-incision laparoscopic cholecystectomy. Curcillo et al. [60] also reported a large multi-institutional series of 297 patients that demonstrated safe and acceptable results with this technique. Caution must be urged, however, with the application of these techniques in light of improvements over standard laparoscopic cholecystectomy. With the rising popularity of laparoscopic cholecystectomy in the 1990s, there was indeed an increased incidence of major biliary injuries compared with open surgery counterparts, and this still exists. Single-incision cholecystectomy probably does not represent as significant a paradigm shift as that encountered in era of change from laparoscopic to open surgery, but indeed, major biliary injury is of prime concern with this technique.

The initial human experience with the current da Vinci Single-Site platform demonstrated several of its limitations. For patients with thicker abdominal walls, significant reverse Trendelenburg positioning resulted in dislodgement of the trocar and consequent loss of pneumoperitoneum. This required undocking of the robot and repositioning of the trocar, which means a much longer operative time.

The studies on single-site robotic cholecystectomy published so far have demonstrated that robotic single-site cholecystectomy can be performed with high standards of safety and efficacy by general surgeons experienced with robotic surgery. Moreover, most of the authors have shown that the robotic technology is a compensatory technique that can overcome the constraints and the ergonomic limitations of SILS and is potentially capable to realize the full potential of the single-access approach.

14.5 Single-Port Robotic Surgery: New Perspectives

The current da Vinci system have shown to be a valuable ally in LESS even if is not what it was specifically designed for. However, the lack of EndoWrist technology at the instrument tips, which probably has represented the main feature of robotic surgery as compared with standard laparoscopy, remains a major limitation. The ideal robotic platform for LESS should have a low external profile, the possibility of being deployed through a single-access site, and the possibility of restoring intra-abdominal triangulation while maintaining the maximum degree of freedom for precise maneuvers and strength for reliable traction. Several robotic prototypes for single-port surgery are being tested. The SPRINT (Single-Port Laparoscopy Bimanual Robot) is part of a major ARAKNES (Array of Robots Augmenting the Kinematics of Endoluminal Surgery) program coordinated by Dario and Cuschieri and funded by the EU Framework 7 program. This robot, which is intended to be used in association with the Karl Storz ENDOCONE, has a three-dimensional high-definition television imaging system and is operated through a console in the sterile field so that the surgeon is not remote from the patient.

Laparoendoscopic single-site surgery (LESS) is currently constrained by the existing instrumentation, which limits the surgeon's ability to visualize and dexterously manipulate within the surgical environment. The existing instruments for these procedures are based on modified laparoscopic tools or a flexible endoscopy platform. All of these instruments are still limited in dexterity due to the confined insertion space and inability to triangulate. There are a number of technical limitations with the miniature surgical robot that need to be addressed. The robot is too large and needs to have its joints narrowly positioned to improve its reach. We had to reposition the robot each time that we needed to move from one procedure to another and several times within each procedure. In the future, the issue of repositioning could be managed with a remotely controlled robotic arm or by an active, bedside assistant. Because of the single-incision nature of the insertion, it was often difficult to get the robot inside through a reasonably sized hole. Subsequently, we had to enlarge the incision and subsequently used the robot as the only operation guide. A smaller and more robust robot would be able to perform surgeries through a single incision without these limitations. These robotic devices are undergoing continuous improvements. One of the fundamental modifications is to reduce the size of the robot.

Miniature robots are inserted entirely into the peritoneal cavity for laparoscopic and natural orifice transluminal endoscopic procedures. These robots can provide vision and task assistance without the constraints of entry-port incisions. Miniature robots have the potential to bring about changes in modern surgery, as did laparoscopic surgery in the 1980s.

In particular, minirobots may enable surgeons to overcome challenges of eye–hand dissociation, replace a two-dimensional field of view with a three-dimensional one, and improve dexterity by increasing the freedom of working instruments.

Because they are small, multiple robots can be deployed given a specific task. The possibility of telesurgery can be realized with miniature surgical robots. Future plans involve developing smaller and more agile robots with additional degrees of freedom for more dexterous movement. Such additional freedom of movement will enable the surgeon to approach an area from several directions to avoid tissue–robot collisions and object occlusion. It remains to be seen whether this new technology will be a viable alternative to traditional laparoscopic approaches. Its adoption would require surgeons to gain new skills to perform complex procedures. It has the potential to be a major innovation in surgery of the twenty-first century, provided it is safe for patients and can achieve equal or better results when compared to the techniques being replaced.

References

1. Box G, Averch T, Cadeddu J et al (2008) Nomenclature of natural orifice translumenal endoscopic surgery (NOTES) and laparoendoscopic single-site surgery (LESS) procedures in urology. J Endourol 22:2575–2578
2. Autorino R, Cadeddu JA, Desai MM et al (2011) Laparoendoscopic single site and natural orifice transluminal endoscopic surgery in urology: a critical analysis of the literature. Eur Urol 59:26–45
3. Gettman MT, White WM, Aron M et al (2011) Where do we really stand with LESS and NOTES? Eur Urol 59:231–234
4. Raman JD, Bagrodia A, Cadeddu JA (2009) Single-incision, umbilical laparoscopic versus conventional laparoscopic nephrectomy: a comparison of perioperative outcomes and short-term measures of convalescence. Eur Urol 55:1198–1206
5. Canes D, Berger A, Aron M et al (2010) Laparo-endoscopic single site (LESS) versus standard laparoscopic left donor nephrectomy: matched-pair comparison. Eur Urol 57:95–101
6. Kaouk JH, Autorino R, Kim FJ et al (2011) Laparoendoscopic single-site surgery in urology: worldwide multi-institutional analysis of 1076 cases. Eur Urol 60:998–1005
7. Greco F, Cindolo L, Autorino R et al (2012) Laparoendoscopic single-site upper urinary tract surgery: assessment of postoperative complications and analysis of risk factors. Eur Urol 61:510–516
8. Haber GP, Autorino R, Laydner H et al (2012) SPIDER surgical system for urologic procedures with laparoendoscopic single-site surgery: from initial laboratory experience to first clinical application. Eur Urol 61:415–422
9. White MA, Haber GP, Autorino R et al (2010) Robotic laparoendoscopic single-site surgery. BJU Int 106:923–927
10. Rane A, Autorino R (2011) Robotic natural orifice translumenal endoscopic surgery and laparoendoscopic single-site surgery: current status. Curr Opin Urol 21:71–77
11. Spana G, Rane A, Kaouk JH (2011) Is robotics the future of laparoendoscopic single-site surgery (LESS)? BJU Int 108:1018–1023
12. Rane' A, Tan GY, Tewari AK (2009) Laparo-endoscopic single-site surgery in urology: is robotics the missing link? BJU Int 104:1041–1043

13. Kaouk JH, Goel RK, Haber GP et al (2009) Robotic single-port transumbilical surgery in humans: initial report. BJU Int 103:366–369
14. Tang B, Hou S, Cuschieri SA (2012) Ergonomics of and technologies for single-port laparoscopic surgery. Minim Invasive Ther Allied Technol 21:46–54
15. Escobar PF, Starks D, Fader AN, Catenacci M, Falcone T (2010) Laparoendoscopic single-site and natural orifice surgery in gynecology. Fertil Steril 94:2497–2502 [16]
16. Joseph RA, Goh AC, Cuevas SP et al (2010) "Chopstick" surgery: a novel technique improves surgeon performance and eliminates arm collision in robotic single-incision laparoscopic surgery. Surg Endosc 24:1331–1335
17. Joseph RA, Salas NA, Johnson C et al (2010) Chopstick surgery: a novel technique enables use of the da Vinci robot to perform single-incision laparoscopic surgery [video]. Surg Endosc 24:3224
18. Allemann P, Leroy J, Asakuma M, Al Abeidi F, Dallemagne B, Marescaux J (2010) Robotics may overcome technical limitations of single-trocar surgery: an experimental prospective study of Nissen fundoplication. Arch Surg 145:267–271
19. Sugimoto M, Tanaka K, Matsuoka Y et al (2011) da Vinci robotic single-incision cholecystectomy and hepatectomy using single-channel GelPort access. J Hepatobiliary Pancreat Sci 18:493–498
20. Tracy CR, Raman JD, Cadeddu JA, Rane A (2008) Laparoendoscopic single-site surgery in urology: where have we been and where are we heading? Nat Clin Pract Urol 5(10):561–568
21. Ostrowitz MB, Eschete D, Zemon H, DeNoto G (2009) Robotic-assisted single-incision right colectomy: early experience. Int J Med Robot 5(4):465–470
22. Barret E, Sanchez-Salas R, Kasraeian A et al (2009) A transition to laparoendoscopic single-site surgery (LESS) radical prostatectomy: human cadaver experimental and initial clinical experience. J Endourol 23:135–140
23. Hagen ME, Wagner OJ, Inan I et al (2010) Robotic single-incision transabdominal and transvaginal surgery: initial experience with intersecting robotic arms. Int J Med Robot 6(3):251–255
24. Desai MM, Aron M, Berger A et al (2008) Transvesical robotic radical prostatectomy. BJU Int 102(11):1666–1669
25. Ragupathi M, Ramos-Valadez DI, Pedraza R, Haas EM (2010) Robotic-assisted single-incision laparoscopic partial cecectomy. Int J Med Robot 6(3):362–367
26. Stein RJ, White WM, Goel RK et al (2010) Robotic laparoendoscopic single-site surgery using GelPort as the access platform. Eur Urol 57(1):132–136
27. Arkoncel FRP, Lee JW, Rha KH et al (2011) Two-port robot-assisted vs standard robot-assisted laparoscopic partial nephrectomy: a matched-pair comparison. Urology 78(3):581–585, 44
28. Wren SM, Curet MJ (2011) Single-port robotic cholecystectomy: results from a first human use clinical study of the new da Vinci single- site surgical platform. Arch Surg 146(10): 1122–1127
29. Kaouk JH, Goel RK (2009) Single-port laparoscopic and robotic partial nephrectomy. Eur Urol 55(5):1163–1169
30. Escobar PF, Fader AN, Paraiso MF et al (2009) Robotic-assisted laparoendoscopic single-site surgery in gynecology: initial report and technique. J Minim Invasive Gynecol 16(5):589–591, 25
31. Fader AN, Escobar PF (2009) Laparoendoscopic single-site surgery (LESS) in gynecologic oncology: technique and initial report. Gynecol Oncol 114(2):157–161, 26
32. White WM, Haber G-P, Goel RK et al (2009) Single-port urological surgery: single-center experience with the first 100 cases. Urology 74(4):801–804, 27
33. Romanelli JR, Roshek TB, Lynn DC 3rd, Earle DB (2010) Single-port laparoscopic cholecystectomy: initial experience. Surg Endosc 24(6):1374–1379, 28
34. Haber G-P, White MA, Autorino R et al (2010) Novel robotic da Vinci instruments for laparoendoscopic single-site surgery. Urology 76(6):1279–1282
35. Escobar PF, Kebria M, Falcone T (2011) Evaluation of a novel single- port robotic platform in the cadaver model for the performance of various procedures in gynecologic oncology. Gynecol Oncol 120(3):380–384, 31

36. Kroh M, El-Hayek K, Rosenblatt S et al (2011) First human surgery with a novel single-port robotic system: cholecystectomy using the da Vinci single-site platform. Surg Endosc 25(11):3566–3573
37. Morel P, Hagen ME, Bucher P et al (2011) Robotic single-port cholecystectomy using a new platform: initial clinical experience. J Gastrointest Surg 15(12):2182–2186, 34
38. White MA, Autorino R, Spana G et al (2011) Robotic laparoendoscopic single-site radical nephrectomy: surgical technique and comparative outcomes. Eur Urol 59(5):815–822, 35
39. Greco F, Veneziano D, Wagner S et al (2012) Laparoendoscopic single-site radical nephrectomy for renal cancer: technique and surgical outcomes. Eur Urol 62:168–174
40. Wang GJ, Afaneh C, Aull M et al (2011) Laparoendoscopic single site live donor nephrectomy: single institution report of initial 100 cases. J Urol 186:2333–2337
41. Stolzenburg JU, Do M, Haefner T et al (2011) Laparoendoscopic single-site surgery radical nephrectomy. J Endourol 25:159–165, 28
42. Park JH, Walz MK, Kang SW et al (2011) Robot-assisted posterior retroperitoneoscopic adrenalectomy: single port access. J Korean Surg Soc 81(Suppl 1):S21–S24 [34]
43. Kaouk JH, Goel RK, Haber GP, Crouzet S, Desai MM, Gill IS (2008) Single-port laparoscopic radical prostatectomy. Urology 72:1190–1193 [38]
44. Barret E, Sanchez-Salas R, Kasraeian A et al (2009) A transition to laparoendoscopic single-site surgery (LESS) radical prostatectomy: human cadaver experimental and initial clinical experience. J Endourol 23:135–140
45. Barret E, Sanchez-Salas R, Cathelineau X et al (2009) Re: initial complete laparoendoscopic single-site surgery robotic assisted radical prostatectomy (LESS-RARP). Int Braz J Urol 35:92–93
46. White MA, Haber GP, Autorino R et al (2010) Robotic laparoendoscopic single-site radical prostatectomy: technique and early outcomes. Eur Urol 58:544–550 [42]
47. Desai MM, Fareed K, Berger AK et al (2010) Single-port transvesical enucleation of the prostate: a clinical report of 34 cases. BJU Int 105:1296–1300
48. Fareed K, Zaytoun OM, Autorino R et al (2012) Robotic single port suprapubic transvesical enucleation of the prostate (R-STEP): initial experience. BJU Int 110:732–737 [44]
49. Cela V, Freschi L, Simi G, Ruggiero M, Tana R, Pluchino N (2013) Robotic single-site hysterectomy: feasibility, learning curve and surgical outcome. Surg Endosc 27:2638–2643
50. Fagotti A, Corrado G, Fanfani F et al (2013) Robotic single-site hysterectomy (RSS-H) vs. laparoendoscopic single-site hysterectomy (LESS-H) in early endometrial cancer: a double-institution case-control study. Gynecol Oncol 130:219–223
51. Vizza E, Corrado G, Mancini E et al (2013) Robotic single-site hysterectomy in low risk endometrial cancer: a pilot study. Ann Surg Oncol. doi:10.1245/s10434-013-2922-9 [Online March 7, 2013]
52. Bogliolo S, Cassani C, Babilonti L, Musacchi V, Nappi RE, Spinillo A (2013) Robotic single site hysterectomy with bilateral salpingo-oophorectomy in female to male transsexualism. J Sex Med. doi:10.1111/jsm.12356
53. Bogliolo S, Cassani C, Babilonti L, Spinillo A (2013) Vaginal cuff closure during robotic single-port hysterectomy: is vaginal route always the best one? Surg Endosc. doi:10.1007/s00464-013-3106-1
54. Uccella S, Ghezzi F, Mariani A, Cromi A, Bogani G, Serati M, Bolis P (2011) Vaginal cuff closure after minimally invasive hysterectomy: our experience and systematic review of the literature. Am J Obstet Gynecol 205:119.e1–12
55. Spinoglio G, Lenti LM, Maglione V et al (2012) Single-site robotic cholecystectomy (SSRC) versus single-incision laparoscopic cholecystectomy (SILC): comparison of learning curves. First European experience. Surg Endosc 26:1648–1655
56. Konstantinidis KM, Hirides P, Hirides S, Chrysocheris P, Georgiou M (2012) Cholecystectomy using a novel single-site(1) robotic platform: early experience from 45 consecutive cases. Surg Endosc 26:2687–2694
57. Pietrabissa A, Sbrana F, Morelli L, Badessi F, Pugliese L, Vinci A, Klersy C, Spinoglio G (2012) Overcoming the challenges of single-incision cholecystectomy with robotic single-site technology. Arch Surg 147(8):709–714

58. Vidal O (2009) Laparoendoscopic single-site cholecystectomy: a safe and reproducible alternative. J Laparoendosc Adv Surg Tech A 19:599–602
59. Hodgett SE et al (2009) Laparoendoscopic single-site (LESS) cholecystectomy. J Gastrointest Surg 13:188–192, 14
60. Curcillo PG II et al (2010) Single-port-access (SPA) cholecystectomy: a multi-institutional report of the first 297 cases. Surg Endosc 24:1854–1860, 3