Chapter 2
Concept of Reduced Port Laparoscopic Surgery

Toshiyuki Mori

Abstract Since the first report of single-incision laparoscopic surgery (SLS) for gallbladder removal by Navarra in 1997, a number of approaches have been reported in the literature. Nevertheless, SLS failed to attract the wide attention of surgeons, because it violated a basic principle known as "triangular formation" resulting in a clashing problem between the scope and instruments. Surgical maneuver became technically demanding with these approaches. A new proposal for SLS with a new accessing device (SILS™ port (Covidien, New Haven, CT, USA)) and bendable forceps (Roticulator™ (Covidien)) was successful, and it reminded surgeons of the promise of SLS, and again proposed it as a viable next-generation surgical technique. Needle-scopic surgery was invented around the same time (1996) and evolved gradually. After the introduction of SLS, many surgeons took note of the pros and cons of SLS and needle-scopic surgery and that they are complementary to each other and the mixed use of the two techniques drastically mitigates the difficulty in SLS. Surgeons started using needle instruments as an active forceps. These approaches are collectively called reduced port laparoscopic surgery (RPLS). Robot and natural orifices translumenal endoscopic surgery (NOTES) devices have reportedly been used as tools of RPLS. The most appropriate combination of these tools would suggest the future shape of minimally invasive surgery.

Keywords Laparoscopic surgery • Single-incision surgery • Reduced port surgery

T. Mori (✉)
Kyorin University, 6-20-2 Shinkawa, Mitaka, Tokyo 181-8611, Japan
e-mail: mori@ks.kyorin-u.ac.jp

T. Mori and G. Dapri (eds.), *Reduced Port Laparoscopic Surgery*,
DOI 10.1007/978-4-431-54601-6_2, © Springer Japan 2014

2.1 Introduction

Although begun in the early 1900s, laparoscopy had limited applications. In 1986, a small CCD camera (small enough to be attached to the eye-piece of the laparoscope) was developed. This enabled all members of the surgical team to share the image of the surgical field inside the body cavity displayed on the monitor. In 1987, video-endoscopic cholecystectomy was first achieved by Mouret, and dramatic increase in adoption occurred in the late 1980s and early 1990s [1].

Since that time, laparoscopic surgery has then been applied to a variety of surgical fields. It became a less invasive alternative to the standard open wound procedures and accepted as standard care in many diseases.

Laparoscopic surgery was performed via accessing channel (port). Less destruction in the normal structure of the body wall was attributed to drastic reduction in surgical invasiveness [2]. Patients who underwent laparoscopic procedures experienced less pain, shorter hospital stay, and returned to normal activity much faster when compared to comparable open procedures. It did not take long for the pioneering surgeons to make further efforts to minimize the number and size of the port and the caliber of the devices with a belief that less destruction of the body wall would result by further reduction of surgical invasiveness [3]. Although it has been difficult to scientifically prove that these approaches could offer better outcomes to patients when compared to standard laparoscopic surgery, three port (even two port) surgery has been practiced in the pioneering centers, and reportedly been better or, at least, comparable to the standard laparoscopic procedures [4, 5]. One of the goals of these approaches is single incision laparoscopic surgery (SLS), in which the access to the body cavity is created via a small wound (i.e. the umbilicus). Dr. Navarra is usually credited with the first single incision laparoscopic cholecystectomy in humans [6]. Natural orifices translumenal endoscopic surgery (NOTES) has been thought of as the ultimate goal of these approaches [7, 8]. It can theoretically negate injury to the normal body wall, resulting in even further lessening of invasiveness. Nevertheless, NOTES is still considered as one of the future options of surgery, because of imperfect instrumentation and technical difficulty to date. Another approach to reduce body wall injury includes needle-scopic surgery, first advocated by Gagner in 1996 [9] and reported by Tanaka in 1997 [10], in which small caliber camera and instruments (<3 mm) are used. The resulting wound is just a puncture hole and almost invisible. Reduced port laparoscopic surgery (RPLS) is a relatively new term, first coined by Curcillo in 2010. Although the definition is still ambiguous, it is generally accepted to use the term ‘reduced port surgery’ to describe a condition where these approaches of minimally invasive surgery are in mixed use, as to reduce invasiveness of the procedure and provide good cosmetic results while maintaining visibility of the surgical field and permitting intuitive handling of the instruments, thus promoting patient safety.

2.2 Single-Incision Laparoscopic Surgery (SLS)

Since the first report of SLS by Navarra [6], a number of approaches have been reported in the literature [11–15]. It was in 2009 that SLS first gained wide acceptance by surgeons. In a seminar of the society of american gastrointestinal and endoscopic surgeons (SAGES), attendants voted for SLS to be the primary access method in a few years for relatively simple laparoscopic procedures (e.g. laparoscopic cholecystectomy for non-inflamed gallbladder). Many manufactures and venders of laparoscopic instruments have noticed the importance of the market for SLS, and have started providing new tools and gadgets (even without scientific verification). Some of the instruments that seemed already obsolete or less functional in standard laparoscopic surgery have been revived for use in SLS [16].

2.3 Characteristics of SLS

Laparoscopic surgery is generally more technically demanding when compared to the comparable open wound surgery. Visual perception is limited for two-dimensional display of the surgical field in laparoscopic surgery. Long and leveraged instruments make surgical maneuvers awkward. Loss of tactile and kinesthetic sensation in laparoscopic surgery further adds difficulty in recognition of surgical anatomy. Use of multiple instruments sometimes resulted in "sword fighting" between the scope and instruments. To cope with these problems, basic principles should always be adhered to reduce difficulty in surgical maneuvers and thus to promote patient safety. Among these principles, co-axial set-up and triangular formation of the instrument are most important. Co-axial set-up means that the monitor, surgical field, camera port, and the operator are ideally placed in a line (Fig. 2.1). Triangular formation is a principle of port placement for the operator, in which instruments from both sides make an angle of 30–60° to the line (axis) mentioned above (Fig. 2.2). With this set-up, the gap between visual perception and surgical exertion can be minimized (eye-hand coordination), avoiding mutual interference of the scope and instruments [17, 18].

In SLS, the ports for scope and instruments are placed in a restricted area, the angles between the scope and instruments are less than 10° at the surgical site. The principle of triangular formation is violated, which imposes problems that are not usual in standard laparoscopic surgery.

The shaft of the instruments and the scope interfere with each other ("sword fighting"). In standard laparoscopic surgery, the length of the instruments is uniformly 33–35 cm. This fact adds clashing problems, in which the handles of instruments interfere with each other outside the abdomen. The relatively large housing of regular ports also clash. In addition, the light guide in a rigid angled scope and the camera head further complicate this clashing problem. Furthermore, the shaft of the instruments tends to eclipse the surgical field for this narrow angle, making it difficult to see the exact place where the force and energy is applied (Fig. 2.3) [16].

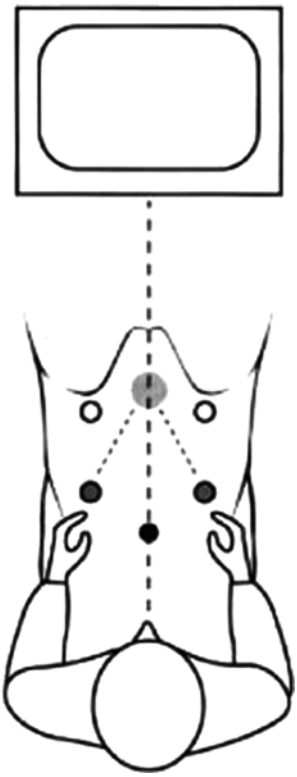

Fig. 2.1 Co-axial setup. Monitor, surgical field, camera port, and the operator are ideally placed in a line

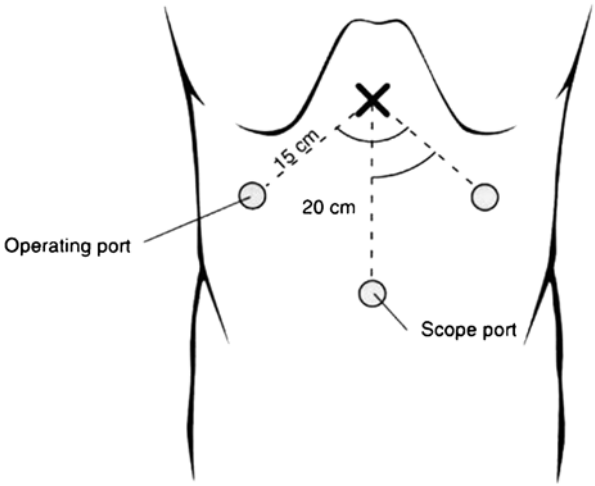

Fig. 2.2 Triangular formation. Instruments from both sides should make an angle of 30° to 60° to the line (*axis*) mentioned above

Fig. 2.3 Eclipse of the surgical field. Because of the narrow angle between the scope and instrument, the shaft of the instrument tends to eclipse the surgical site where the force and energy is applied

2.4 Instrumentation and Techniques in SLS

Regardless of the names, including SILS™ (Single-Incision Laparoscopic Surgery, Covidien http://www.covidien.com/), LESS™ (Laparo-Endoscopic Single-Site surgery, Olympus http://www.olympusamerica.com/LESS/, http://www.advancedsurgical.ie/), SSL™ (Single Site Laparoscopy J&J http://www.jnj.com/connect/), and S-Portal™ (Karl Storz Endoskope, http://www.karlstorz.com/cps/rde/xchg/karlstorz-en/hs.xsl/146.htm), the underlying concept is almost identical, restoration of triangular formation while avoiding clash and "sword fighting." In order to restore triangular formation, two basic techniques have been employed, first placing the operating ports at a good distance of separation from one another, and second using curved, angulated, or articulated instruments. The first technique is commonly referred to as the parallel technique, and the second one as the cross hand technique (Figs. 2.4 and 2.5). In clinical settings, these techniques are often in mixed use. Tissue retraction is a key step of operation for good exposure of the surgical field with some tension to apply force and energy to the surgical site. In standard laparoscopic surgery, the assisting forceps is inserted through an independent port to achieve this. In SLS, additional instruments from the same wound further complicate the clashing problem. Sutures are introduced in the abdominal cavity from a different site and the tissue is pierced, and then the sutures are retrieved through the abdominal wall. By pulling the thread outside, the tissue is retracted. Although some surgeons advocate this technique, it is cumbersome and sometimes causes bile spillage in laparoscopic cholecystectomy. Gadgets that measure 1.6–3 mm in caliber, including pre-tied loop, wire snare, and a needle grasper can be independently

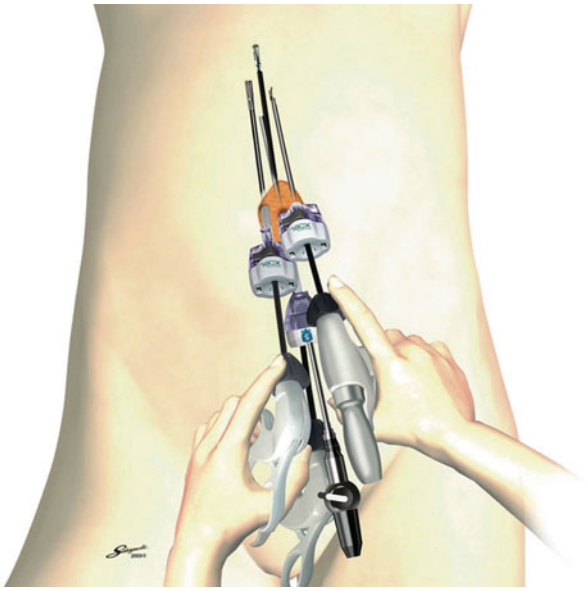

Fig. 2.4 Parallel Technique (Boxing Style). In parallel technique, the operating ports are placed at a distance of 1.5–2.5 cm away from the scope port

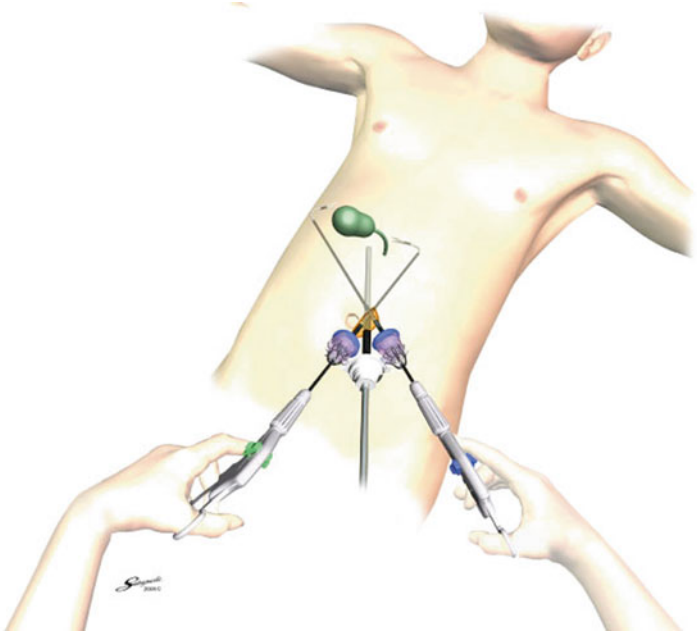

Fig. 2.5 Cross Hand Technique. In the cross hand technique, the shafts of the instrument cross at some point and the instrument that approaches the surgical site from the left-side is manipulated by the right hand

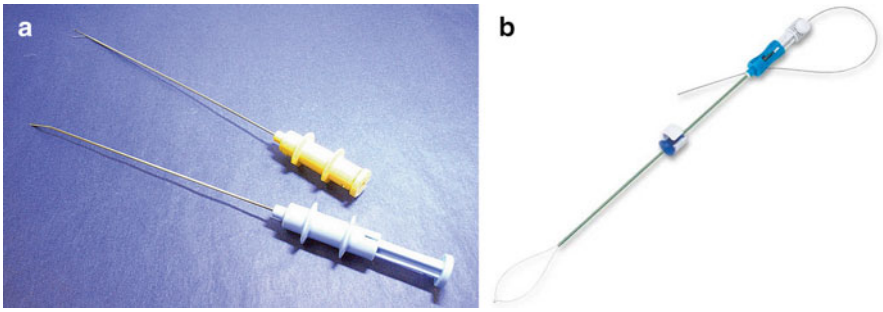

Fig. 2.6 Gadgets for Tissue Retraction. (**a**) Riza-Ribe Needle and GraNee Needle (M-Med). (**b**) Mini loop retractor (Covidien)

inserted elsewhere as in standard laparoscopic operations and used for tissue retraction (Fig. 2.6). The use of additional instruments adds confusion to the terminology of SLS, because these techniques leave an additional wound, even though small and in name, scarless. The purists of SLS demanded that these techniques requiring another wound should be distinguished from the pure one, resulting in further confusion of the terminology including with one additional port surgery, single plus one port laparoscopic surgery, or two-port laparoscopic surgery [19–21].

2.5 Needle-Scopic Surgery

Although the term needle-scopic surgery was first used in 1996 by Mathias [22], Tanaka in 1997 is usually credited with the first report of needle-scopic cholecystectomy in humans [10]. This report was followed by a number of clinical reports from various fields of surgery [23–25]. The merits of needle-scopic surgery included its cosmetic advantage over standard laparoscopic surgery while keeping the operability of instruments. Several randomized control studies were conducted, but failed to prove the better outcome of needle-scopic cholecystectomy when compared to standard laparoscopic cholecystectomy in regard to postoperative pain, convalescence and recovery [26–28]. The disadvantages of needle-scopic surgery result from the small caliber of the scope and instruments. The image that needle-scope provides is unsatisfactory. The shaft of the forceps bends when force is applied, and the small jaws of instruments tend to bite the organs more easily than atraumatically-designed jaws of standard laparoscopic instruments.

In a meta-analysis by Sajid et al. [29], needle-scopic cholecystectomy was reportedly associated with longer operating time and higher conversion rate comparing to standard laparoscopic cholecystectomy. Although needle-scopic surgery has been routinely performed for relatively simple procedures in pioneering institutions, it failed to gain wide acceptance as a standard procedure to date.

2.6 Inception of Reduced Port Laparoscopic Surgery (RPLS)

In general, SLS is more technically demanding than standard laparoscopic surgery. In the beginning, indications suggested that it was limited to relatively simple operations. Many surgeons have noticed that the pros and cons that SLS and needlescopic surgery bring are complementary to each other and the mixed use of two techniques drastically mitigate difficulties in SLS. Surgeons started using needle instruments as an active forceps [30]. These approaches are collectively called RPLS. Unleashed from the limitations of SLS, RPLS widened its indication to a variety of procedures, as is described in this book. Interestingly, the introduction of RPLS evoked the idea of hybrid use of other approaches of minimally invasive surgery, including robotic surgery and NOTES [31, 32]. The daVinci single-site platform (Intuitive Surgical Inc., Sunnyvale, CA, USA) is already on the market (Fig. 2.7), and endoscopic robot designed for NOTES was introduced through an access device of SLS. A flexible endoscope is also introduced through the single access device, and the endoscopic device through the working channel is used as a forceps in cooperation with standard instruments [33]. Assisting forceps were reportedly introduced through the port placed in the vagina, and the specimen was eventually retrieved via the vagina [34]. Various approaches to minimize invasiveness of surgery merge here in reduced port laparoscopic surgery. In the toolbox of RPLS, we have a wide variety of tools, including standard and needle-scopic instruments, robots, NOTES devices, and even the flexible endoscope and its various forceps (Fig. 2.8).

Fig. 2.7 Single Site daVinci (Intuitive). Single incision robotic surgery is already in clinical use

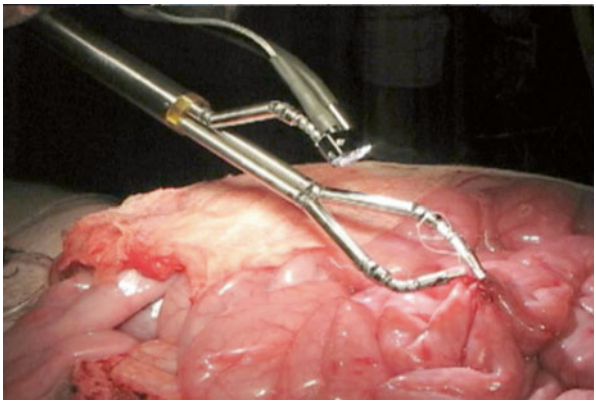

Fig. 2.8 NOTES device. NOTES device can also be used in reduced port laparoscopic surgery

2.7 Future of Minimally Invasive Surgery

It is hardly possible to predict even the near future of minimally invasive surgery. Although technically feasible, RPLS is still in its infancy. The optimal combination of the hybrid use of a list of tools should be discussed from various points of view. The middle and long-term outcome of RPLS, especially for malignant diseases, should be extensively studied. One thing for sure is that patient preference would be a minimal wound. A short-as-possible convalescence and leave period is most desirable, as far as the selected treatment, RPLS, can give better or, at least comparable outcome to standard (laparoscopic) surgery. I believe that RPLS would be the mainstay of accessing method in minimally invasive surgery.

References

1. Polychronidis A, Laftsidis P, Bounovas A, Simopoulos C (2008) Twenty years of laparoscopic cholecystectomy: Philippe Mouret–March 17, 1987. JSLS 12(1):109–111
2. Cho JM, LaPorta AJ, Clark JR, Schofield MJ, Hammond SL, Mallory PL 2nd (1994) Response of serum cytokines in patients undergoing laparoscopic cholecystectomy. Surg Endosc 8:1380–1384
3. Matsuda T, Ogura K, Uchida J, Fujita I, Terachi T, Yoshida O (1995) Smaller ports result in shorter convalescence after laparoscopic varicocelectomy. J Urol 153:1175–1177
4. Sun S, Yang K, Gao M, He X, Tian J, Ma B (2009) Three-port versus four-port laparoscopic cholecystectomy: meta-analysis of randomized clinical trials. World J Surg 33:1904–1908
5. Poon CM, Chan KW, Lee DW, Chan KC, Ko CW, Cheung HY, Lee KW (2003) Two-port versus four-port laparoscopic cholecystectomy. Surg Endosc 17:1624–1627
6. Navarra G, Pozza E, Occhionorelli S, Carcoforo P, Donini I (1997) One-wound laparoscopic cholecystectomy. Br J Surg 84(5):695
7. 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 142:823–827

8. Forgione A, Maggioni D, Sansonna F, Ferrari C, Di Lernia S, Citterio D, Magistro C, Frigerio L, Pugliese RJ (2008) Transvaginal endoscopic cholecystectomy in human beings: preliminary results. J Laparoendosc Adv Surg Tech A 18:345–351
9. Gagner M, Garcia-Ruiz A (1998) Technical aspects of minimally invasive abdominal surgery performed with needlescopic instruments. Surg Laparosc Endosc 8(3):171–179
10. Tanaka J, Andoh H, Koyama K (1998) Minimally invasive needlescopic cholecystectomy. Surg Today 28(1):111–113
11. Podolsky ER, Curcillo PG 2nd (2010) Reduced-port surgery: preservation of the critical view in single-port-access cholecystectomy. Surg Endosc 24(12):3038–3043
12. Cuesta MA, Berends F, Veenhof AA (2008) The "invisible cholecystectomy": a transumbilical laparoscopic operation without a scar. Surg Endosc 22:1211–1213
13. Gumbs AA, Milone L, Sinha P, Bessler M (2009) Totally transumbilical laparoscopic cholecystectomy. J Gastrointest Surg 13(3):533–534
14. Hong TH, You YK, Lee KH (2009) Transumbilical single-port laparoscopic cholecystectomy: scarless cholecystectomy. Surg Endosc 23:1393–1397
15. Rivas H, Varela E, Scott D (2010) Single-incision laparoscopic cholecystectomy: initial evaluation of a large series of patients. Surg Endosc 24(6):1403–1412
16. Mori T, Aoki H, Sugiyama M, Atomi Y (2010) Instrumentation of single-access laparoscopic surgery. Asian J Endosc Surg 3:153–161
17. Bhoyrul S, Mori T, Way LW (1995) Principles of instrumentation. In: Way LW, Bhoyrul S, Mori T (eds) Fundamentals of laparoscopic surgery. Churchill Livingstone, New York, NY, pp 13–78
18. Mori T, Bhoyrul S, Way LW (1995) Operative techniques. In: Way LW, Bhoyrul S, Mori T (eds) Fundamentals of laparoscopic surgery. Churchill Livingstone, New York, NY, pp 79–136
19. Gao Y, Xu DF, Liu YS, Cui XG, Che JP, Yao YC, Yin L (2011) Single plus one port laparoscopic radical prostatectomy: a report of eight cases in one center. Chin Med J (Engl) 124(10):1580–1582
20. Lim SW, Kim HJ, Kim CH, Huh JW, Kim YJ, Kim HR (2013) Umbilical incision laparoscopic colectomy with one additional port for colorectal cancer. Tech Coloproctol 17(2):193–199
21. Kikuchi I, Kumakiri J, Matsuoka S, Takeda S (2012) Learning curve of minimally invasive two-port laparoscopic myomectomy. JSLS 16(1):112–118
22. Mathias JM (1997) Needlescopic surgery is painless and scarless. OR Manager 13(11):24, 26–27
23. Gill IS, Soble JJ, Sung GT, Winfield HN, Bravo EL, Novick AC (1998) Needlescopic adrenalectomy–the initial series: comparison with conventional laparoscopic adrenalectomy. Urology 52(2):180–186
24. Tagaya N, Kita J, Kogure H, Kubota K (2001) Laparoscopic intragastric resection of gastric leiomyoma using needlescopic instruments. Case report. Surg Endosc 15(4):414
25. Mamazza J, Schlachta CM, Seshadri PA, Cadeddu MO, Poulin EC (2001) Needlescopic surgery. A logical evolution from conventional laparoscopic surgery. Surg Endosc 15(10):1208–1212
26. Lee PC, Lai IR, Yu SC (2004) Minilaparoscopic (needlescopic) cholecystectomy: a study of 1,011 cases. Surg Endosc 18(10):1480–1484
27. Franklin ME Jr, Jaramillo EJ, Glass JL, Treviño JM, Berghoff KR (2006) Needlescopic cholecystectomy: lessons learned in 10 years of experience. JSLS 10(1):43–46
28. Tagaya N, Rokkaku K, Kubota K (2007) Needlescopic cholecystectomy versus needlescope-assisted laparoscopic cholecystectomy. Surg Laparosc Endosc Percutan Tech 17:375–379
29. Sajid MS, Khan MA, Ray K, Cheek E, Baig MK (2009) Needlescopic versus laparoscopic cholecystectomy: a meta-analysis. ANZ J Surg 79(6):437–442
30. Leroy J, Cahill RA, Peretta S, Marescaux J (2008) Single port sigmoidectomy in an experimental model with survival. Surg Innov 15:260–265

31. Autorino R, Kaouk JH, Stolzenburg JU, Gill IS, Mottrie A, Tewari A, Cadeddu JA (2013) Current status and future directions of robotic single-site surgery: a systematic review. Eur Urol 63(2):266–280
32. Noguera JF, Dolz C, Cuadrado A, Olea J, García J (2013) Flexible single-incision surgery: a fusion technique. Surg Innov 20(3):256–259
33. Abe N, Takeuchi H, Ohki A, Aoki H, Masaki T, Mori T, Sugiyama M (2012) Single-incision multiport laparoendoscopic surgery using a newly-developed short-type flexible endoscope: a combined procedure of flexible endoscopic and laparoscopic surgery. J Hepatobiliary Pancreat Sci 19(4):426–430
34. Navarra G, Currò G (2010) Trans-vaginally assisted single incision laparoscopic right hemicolectomy. ANZ J Surg 80(12):872–873

http://www.springer.com/978-4-431-54600-9

Reduced Port Laparoscopic Surgery

Mori, T.; Dapri, G. (Eds.)
2014, XX, 527 p. 458 illus., 287 illus. in color.,
Hardcover
ISBN: 978-4-431-54600-9