Video based learning in surgical education: a new modality for hybrid training in minimally invasive surgery.

Valerio Celentano

The thesis is submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy at the University of Portsmouth.

September 2020

Abstract

My research started from the evaluation of the challenges posed by the introduction of laparoscopic surgery and assessing the outcomes of patients undergoing complex colorectal procedures performed laparoscopically. The findings of this preliminary research confirmed the benefits of laparoscopic surgery and therefore highlighted the need for dedicated training pathways, to reduce the long learning curve in minimally invasive surgery. In view of the limited time available in theatre for complex training, my research focused on the role of surgical simulations and video resources to maximise the benefit from the training event. Surgical videos showed favourable characteristics for self-directed learning, time efficiency and constructive feedback. After establishing a paucity of adequate educational content in majority of online videos, I led a multidisciplinary study group for development of consensus guidelines for reporting of educational videos. The use of videos for trainers' feedback sessions also resulted valuable when applied in a pilot study assessing stepwise training in complex Crohn's disease surgery.

Contents

Declaration

Whilst registered for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

Dissemination

Articles:

1. Celentano, V., Giglio, M.C., Bucci, L. (2015). Laparoscopic versus open Hartmann's Reversal: a Systematic Review and Meta-analysis. *Int J Colorectal Dis*. (2015) Dec;30(12):1603-15.

2. Giglio, M.C., Celentano, V., Tarquini, R., Luglio, G., De Palma, G.D., Bucci, L. (2015). Conversion during laparoscopic colorectal resections: a complication or a drawback? A systematic review and meta-analysis of short-term outcomes. *Int J Colorectal Dis*. (2015) Nov; 30(11): 1445-55.

3. Celentano, V., Finch, D., Forster, L., Robinson, J.M., Griffith, J.P. (2015). Safety of supervised trainee performed laparoscopic surgery for inflammatory bowel disease. *Int J Colorectal Dis* (2015) May; 30:639-44

4. Celentano, V., Sagias, F., Flashman, K., Conti, J., Khan, J. (2019). Laparoscopic redo ileocolic resection for Crohn's disease in patients with previous multiple laparotomies. *Scand J Surg*. 2019 Mar;108(1):42-48.

5. Celentano, V. (2015) Need for simulation in laparoscopic colorectal surgery training. *World J Gastrointest Surg*. (2015) 27; 7(9):185-9

6. Celentano, V., Browning, M., Hitchins, C., Giglio, M.C., Coleman, M.G. (2017). Training value of laparoscopic colorectal videos on the World Wide Web: a pilot study on

the educational quality of laparoscopic right hemicolectomy videos. *Surg Endosc*. 2017 Nov;31(11):4496-4504.

7. Celentano, V., Pellino, G., Coleman, M.G. (2019). Lack of online video educational resources for open colorectal surgery training. *ANZ J Surg*. 2019 Mar;89(3):180-183.

8. Celentano, V., Smart, N., Cahill, R.A., McGrath, J.S., Gupta, S., Griffith, J.P., Acheson, A.G., Cecil, T.D., Coleman, M.G. (2018). Use of laparoscopic videos amongst surgical trainees in the United Kingdom. *Surgeon*. 2018 Nov 9. pii: S1479-666X(18)30123-9.

9. Celentano, V., Coleman, M.G. (2016). Laparoscopic extended right hemicolectomy for hepatic flexure cancer: radical primary vascular approach - a video vignette. *Colorectal Disease* (2016) Jan;18(1):110-1.

10. Celentano, V., Smart, N., McGrath, J., Cahill, R.A., Spinelli, A., Obermair, A., Hasegawa, H., Lal, P., Almoudaris, A.M., Hitchins, C.R., Pellino, G., Browning, M.G., Ishida, T., Luvisetto, F., Cingiloglu, P., Gash, K., Harries, R., Harji, D., Di Candido, F., Cassinotti, E., McDermott, F.D., Berry, J.E.A., Battersby, N.J., Platt, E., Campain, N.J., Keeler, B.D., Boni, L., Gupta, S., Griffith, J.P., Acheson, A.G., Cecil, T.D., Coleman, M.G. (2018). LAP-VEGaS practice guidelines for reporting of educational videos in laparoscopic surgery: a joint trainers and trainees consensus statement. Ann Surg. 2018 Dec;268(6):920-926.11.

11. Celentano, V., Flashman, K. (2019). Stepwise training in laparoscopic surgery for complex ileocolonic Crohn's disease: analysis of 127 training episodes. *J Surg Educ*. 2019 Sep-Oct;76(5):1364-1369

Conference presentations:

1. Development of a joint trainers and trainees consensus statement for reporting of educational videos in laparoscopic surgery. – European Society of Coloproctology – Berlin 2017
2. Video demonstration of a stepwise approach for Splenic Flexure Resection Laparoscopic Approach – Italian Society of Surgical Oncology annual meeting – Turin 2017
3. Training video. Four different approaches to laparoscopic redo surgery in recurrent ileocolonic Crohn’s disease. American Society of Colon and Rectal surgery 2019 – Cleveland 2019

Chapter 1.

Introduction

Health and care service delivery face growing challenges that must be overcome in order to meet patient expectations, the highest safety standards and effective use of available resource. Patients living longer (Divo, Martinez, Mannino, 2014, p. 1055), requiring more medical and surgical intervention as well as a lack of health and care staff in training (Fayanju et al, 2017, p. 459) are just two of the significant barriers to the delivery of effective care. Within the surgical field, there have been significant innovations to cope with demand and manage patient expectations over recent years. Key to new innovations is to realise benefits in patient outcomes as well as reducing error consequence through enabling a managed and structured learning environment for trainee surgeons (Curtis et al, 2020, p. 1).

The traditional apprentice model for surgeons in training requires sufficient opportunities and time to learn surgical skills under the direction and supervision of an experienced trainer (Halstead, 1904, p. 267). New surgical and procedural techniques (including minimally invasive surgery) are characterized by changes in performance over time, or the learning curve (Miskovic, Ni, Wyles, Tekkis, Hanna, 2012, p. 1300), which has been recognised as one of the main barriers in surgeons adopting a new technique, alongside costs and lack of incentives from the hospitals (Benmessaoud, Kharrazi, MacDorman, 2011, p.e16395). The operating room represents an essential learning environment which cannot be fully replaced, but with duty hour restrictions, heightened concerns for patient safety and increased levels of staff supervision, surgical trainees report less planned educational time in this learning environment ultimately affecting autonomy (Blencove, Parsons, Hollowood, 2011, p. 795). Additionally, advanced laparoscopic procedures require dedicated surgical skills to overcome specific technical difficulties including two-dimensional vision with loss of depth perception, restricted range of motion of the instruments and impaired tactile sensation (Smith, Farrell, McNatt, Metreveli, 2001, p.547), therefore, laparoscopy does not lend itself to ad hoc or opportunistic learning.

The advent of laparoscopy revolutionised the training paradigm, not only by introducing complexity in the handling of tissues requiring new training pathways, but more importantly by allowing the entire surgical team to have the exact same best view (Hall, 2002, p. 465). Surgeons can record, re-play and review the procedures they perform, or even evaluate how another colleague managed a similar scenario maybe months or years before irrespective of geographical location (Fecso, Bhatti, Stotland, Quereshy, Grantcharov, 2019, p. 115). Minimally invasive surgery platforms facilitate the real-time production of audio-visual materials which are an important educational tool, whist video recording the procedure provides viewers with essential information regarding the anatomy as well as the different steps and challenges of the surgical procedure from the operating surgeon's point of view. Specific benefits offered include watching from the same perspective, drawing arrows or colouring the area of interest to be emphasised or demonstrated; pause the video or jump to the part that learners are really interested in (Loukas, 2018, p.553).

Trainee surgeons are required to gather more technical skills in a shorter time period (Greensmith, Cho, Hargest, 2016, p. 76) and a deficiency of successful performance of enough critical laparoscopic cases by trainees has been reported (Bell et al, 2009, p. 719). The lack of standardisation of expected operative experience in general surgical training alongside different requirements of surgical curricula (Elsey, Griffith, Humes, West, 2017, p.22) could influence the opportunities for gaining experience for the learner and potentially wide variation in the operative exposure of newly qualified surgeons. Expectations are that surgeons must develop new innovative methods of surgical training outside of the surgical theatre to accelerate through the learning curve and realise enhanced patient safety. This model of learning raises questions in several key research areas that required investigation, including:

- Evaluate laparoscopic surgery feasibility and outcomes in complex cases, in whom a prolonged learning curve is to be expected
- Explore the effectiveness of supervised laparoscopic training programmes
- Identify and evaluate alternative ways to augment traditional teaching and learning

The rest of this Chapter provides a personal narrative and explanation of the rest of this thesis including the context and background of the programme of research presented within.

Chapter 2 addresses the first research question, discussing how my research focused on evaluating the advantages of laparoscopic surgery in the complex setting of patients who had a previous emergency surgery for intra-abdominal sepsis, which had traditionally been denied a minimally invasive approach in view of the expected technical challenges (Celentano, Giglio, Bucci, 2015, p. 1603). This evaluation demonstrated that even in these difficult circumstances laparoscopy can be safely performed, with reduced postoperative complications. However, the evaluation highlighted that in many cases where the procedures started with a laparoscopic approach, they had to be “converted” to open surgery, leading me to explore if conversion of a procedure from laparoscopic surgery to open surgery added additional risks for the patients. Subsequently, I co-authored a literature review on conversion rate in colorectal cancer surgery and the resulting postoperative complications and oncological outcomes (Giglio et al, 2015, p. 1445). The main finding was that surgeons at the early stages of the learning curve may have difficulties in completing laparoscopic procedures with a high conversion and complication rate. Based on this analysis, I undertook an investigation to explore the effectiveness of supervised training programs designed to shorten the learning curve and to assess the safety of procedures performed by surgeons in training. For this investigation, I led a study group evaluating the outcomes of surgical procedures performed by surgical trainees (Celentano, Finch, Forster, Robinson, Griffith, 2015, p. 639). This prospective study concluded that laparoscopic surgery for inflammatory conditions such as Crohn’s disease and Ulcerative Colitis could be safely performed by surgical trainees when supervised by experienced trainers, but at the risk and expense of longer operating times. This research also demonstrated the advantages of laparoscopic surgery even in complex cases when performed by highly trained surgeons (Celentano, Sagias, Flashman, Conti, Khan, 2019, p. 42). Augmented rates of adverse clinical outcomes at the beginning of the learning curve introduce ethical questions and emphasise the demand for mechanisms to decrease complications and unnecessary conversions to open surgery during the early stage of independent practice. The theme of shortening the learning curve without compromising outcomes focused my research towards identifying strategies to train surgeons outside of the operating room with surgical simulation. Surgical simulation is reported to develop skills needed for advanced surgical procedures (Gurusamy, Aggarwal, Palanivelu, Davidson, 2009, p. 21), and many studies have demonstrated benefit for surgical trainees (Park et al, 2007, p. 205). Chapter two concludes with my findings demonstrating that simulation may offer a safe, reproducible environment for development of technical skills and procedural knowledge in a setting where no real harm may occur to patients (Celentano, 2015, p. 185).

The findings discussed in Chapter 2 were positive in demonstrating simulation but on its own, simulation was not enough to offer a comprehensive training environment. There was a need to identify learning modalities that were more efficient than simulation and could be used at any time yet were effective. Chapter 3 introduces the concept of audio-visual presentations, which are recognized in medicine as important educational materials and are used to communicate information effectively to clinicians, patients, and students (Ozyurda et al, 2002, p. 189). Laparoscopic surgery is reported to lend itself to the production of educational materials with endoscopy systems with integral video-recording devices, enabling the capture of high-quality images in a digital format (Abdelsattar et al, 2015, p. 145). The video recording of the procedure shows exactly what the surgeon is viewing providing surgical trainees with essential information regarding anatomy and the different steps of the operation. Instructive laparoscopy videos with appropriate exposition could be ideal for initial training in laparoscopic surgery, but the trustworthiness of a large proportion of publicly available files remains questionable as not all videos are authoritative and may not show techniques based on sound evidence (Duncan, Yarwood-Ross, Haigh, 2013, p. 1576). Surgical trainers consider laparoscopic videos as a useful teaching aid to maximize trainees' learning and skill development given the backdrop of time constraints and productivity demands. Preoperative mental coaching leads to improved performance and surgical trainees could ''warm up'' before surgery watching a video showing a step-by-step approach to the surgical procedure they are about to perform (Louridas et al, 2015, p. 37). To evaluate this, I coordinated a study group to evaluate current availability of online surgical videos (Celentano, Browning, Hitchins, Giglio, Coleman, 2017, p. 4496) and their quality in terms of educational content and safety of the procedure presented (Celentano, Pellino, Coleman, 2019, p. 180). These two studies demonstrated lack of high-quality videos, highlighting the need for improvement in view of the discrepancies between the expectations of surgical trainees compared to the available online material, as shown in a UK surgical trainees survey (Celentano et al, 2018, p. 1479).

Crucially for any high quality research, is the ability to enable knowledge exchange and disseminate new findings and Chapter 4 summarises how these findings led to the development of a consensus statement on reporting laparoscopic surgery video for educational purposes in order to achieve high-quality educational videos (Celentano, Coleman, 2016, p. 110) that could improve surgical training (Celentano et al, 2018, p. 920). This international, multispecialty, joint trainers and trainees study group developed guidelines for laparoscopic videos reporting. Hitherto, there was no previously published set of reporting guideline for the presentation of surgical videos and, as such, the quality, reliability and educational rigour of these materials is highly variable. My research findings led to improving the educational value of video outputs, especially if intended for training. The logical progression was to set a reference standard by introducing consensus-led guidance. Acknowledging that videos need to be recorded and presented according to recognised standards confirms that dedicated format and expertise is required for production of highly educational outputs. Nevertheless, surgeons in training may have different knowledge and skillset or simply be at different stages of their training, highlighting the need for tailoring the training resources to maximise learning, I discuss this as “hybrid training”.

Chapter 5 explores the effectiveness of a “hybrid training” model in complex laparoscopic surgery (Celentano, Flashman, 2019, p. 1364) for Crohn’s disease. In this study, every surgical procedure was subdivided into different training modules of increasing complexity and the training episode was tailored to the experience and needs of the surgical trainees. Additionally, by applying consistent peer review of surgical performance with mandatory review of the recording of the performed procedures, the training episode continued even outside the operating room allowing self-directed learning in a convenient setting for the trainer and the trainee, minimising risks to patients and enhancing self-reflection. The chapter concludes with recognising hybrid training as an effective resource to enhance learner centred training in minimally invasive colorectal surgery.

Finally, Chapter 6 draws together the narrative of all of the previous chapters and provides the ‘golden thread’ of findings that inform this programme of research demonstrating my addition to the body of existing knowledge.

Chapter 2. Advantages and challenges of minimally invasive surgery

In this chapter the following peer reviewed manuscripts are discussed:

1. **Celentano, V.**, Giglio, M.C., Bucci, L. (2015). Laparoscopic versus open Hartmann's Reversal: a Systematic Review and Meta-analysis. *Int J Colorectal Dis*. Dec;30(12):1603-15.

   I was the first and corresponding author of this manuscript. My contribution included study design, literature review, data collection and analysis, draft manuscript review, manuscript submission.

2. Giglio, M.C., **Celentano, V.**, Tarquini, R., Luglio, G., De Palma, G.D., Bucci L. (2015). Conversion during laparoscopic colorectal resections: a complication or a drawback? A systematic review and meta-analysis of short-term outcomes. *Int J Colorectal D*is. Nov; 30(11): 1445-55.

   I was the second author of this manuscript. My contribution included literature review, data collection and analysis, draft manuscript review.

3. **Celentano, V.,** Finch, D., Forster, L., Robinson, J.M., Griffith, J.P. (2015). Safety of supervised trainee performed laparoscopic surgery for inflammatory bowel disease. *Int J Colorectal Dis* May; 30:639-44

   I was the first and corresponding author of this manuscript. My contribution included study design, data collection and analysis, draft manuscript review, manuscript submission.

4. **Celentano V**, Sagias F, Flashman K, Conti J, Khan J (2019). Laparoscopic redo ileocolic resection for Crohn's disease in patients with previous multiple laparotomies. *Scand J Surg*. Mar;108(1):42-48.

I was the first and corresponding author of this manuscript. My contribution included study design, data collection and analysis, draft manuscript review, manuscript submission.

5. **Celentano, V. (2015).** Need for simulation in laparoscopic colorectal surgery training. *World J Gastrointest Surg*. 27; 7(9):185-9
I designed the study, conducted the literature review, drafted and submitted the manuscript.

This chapter specifically addresses the research question:

- Evaluate laparoscopic surgery feasibility and outcomes in complex cases, in whom a prolonged learning curve is to be expected

Surgical training has traditionally been one of apprenticeship, based on a Halsted's "see one, do one, teach one" classic scheme (Kerr & O'Leary, 1999, p. 1101) where the surgical trainee learns to perform surgery under the supervision of an experienced surgeon. Performing laparoscopic procedures requires special surgical skills to overcome the technical difficulties that it presents, which include two-dimensional vision with loss of depth perception, less range of motion of the instruments when compared with open surgery, impaired tactile sensation (Scott et al, 2001, p. 137) and the disparity between visual and proprioceptive feedback known as the fulcrum effect (Smith et al, 2001, p. 547). Laparoscopic surgery is difficult to learn by observation and practice alone (Dutta, Gaba, Krummel, 2006, p. 301) and competency requires dedicated training and mentoring (Celentano et al, 2015, p. 639). Moreover, augmented rates of adverse clinical outcomes at the beginning of the learning curve introduce ethical questions and emphasize the demand for mechanisms to decrease complications and unnecessary conversions to open surgery during the early stage of independent practice. As it is no longer accepted that surgeons acquire experience at the expense of patient safety, patients should not be exposed to the opportunity of harm when other training approaches are available for skill acquisition (The Southern Surgeons Club, 1991, p. 1073) and therefore traditional apprenticeship is no longer acceptable.

It has also been demonstrated that the surgical theatre can be a suboptimal place for beginner learning as high stress leads to deleterious effects on performance (Park et al, 2007, p. 205) and surgical training in the operating room implicates additional cost, estimated in approximately United States $47979 per year per trainee (Bridges & Diamond, 1999, p. 28). Concerns including additional cost, time, schedule restriction and the potential for reduced safety have arisen and this forced surgeons to innovate and develop new methods of surgical training (Gurusamy et al, 2009, p. 21; Scott et al, 2000, p. 272) and it became accepted that the learning curve must be abbreviated by learning outside of the surgical theatre (Samia, Khan, Lawrence, Delaney, 2013, p. 47). Committed practice on simulators corresponds with improved operative times and efficiency of movement for minimally invasive cholecystectomy, for example (Aggarwal et al, 2007, p. 771) whose results indicate that the learning curve for laparoscopic colorectal surgery may be reduced with this approach.

However, colonic and rectal resections performed laparoscopically are considered to be more difficult than a cholecystectomy as they involve added challenges like the need to operate within multiple quadrants in the abdominal cavity, the dissection of inflamed or obliterated tissue planes, and the safe mobilization of the bowel from confined spaces (Jamali et al, 2008, p. 762). Laparoscopic colorectal surgery training is less adapt to simple box trainers because of the necessity to work in multiple quadrants, transect and extract often large bulky specimens, and perform bowel anastomosis: advanced surgery needs advanced simulation training. Laparoscopic training has changed the traditional perspective challenging the Halsted’s one century old apprenticeship model (Haltsed, 1904, p. 267), but has also induced a prompt development of simulation techniques given the versatility of the video environment and the capability to monitor the motions of the trainees(Bashankaev, Baido, Wexner, 2011, p. 28). Adequate training therefore, is the desirable way to prevent and mitigate against potential laparoscopic surgical errors (Moore, Bennett, 1995, p. 55).

Laparoscopic techniques for colorectal surgery have been evolving since the early 1990s demonstrating benefits over open techniques in terms of shorter hospital length of stay

(Braga et al, 2005, p. 890), less pain, and quicker return to full activities for the patient (Franklin et al, 1996, p. 35). Despite the evidence for the clinical benefits of laparoscopic surgery and its oncologic safety (Faiz et al, 2009, p. 1695; Hewett et al, 2008, p. 728), the dissemination of this technique has been hesitant, with one of the main constraints for a swift uptake being an extended learning curve (Miskovic et al, 2012, p. 1300). In particular, the high level of technical complexity associated with laparoscopic colectomies was held partially responsible for its relatively low adoption rate when compared with other laparoscopic modalities (Bardakcioglu, Khan, Aldridge, Chen, 2013, p. 270; Kemp & Finlayson, 2008, p. 1181) and learning curves have been estimated as being between 30 and 60 cases (Tekkis, Senagore, Delaney, Fazio, 2005, p. 83; Choi et al, 2009, p. 622) with the need to acquire specific skills dissimilar to those used during conventional surgery (Kim et al, 2007, p. 1503). Laparoscopic colorectal surgery is a technically challenging modality, frequently being self-taught by senior surgeons (Miskovic, Wyles, Ni, Darzi, Hanna, 2010, p. 943), despite this, there is long-standing evidence that the absence of appropriate training may lead to patient safety compromise (The Southern Surgeons Club, 1991, p. 1073; ,Stein, Stulberg, Champagne, 2012, p. 488).

When the operation is not progressing with the laparoscopic approach or if complications arise the surgeon needs to change the strategy and continue with a traditional open approach (Schwandner, Schiedeck, Bruch, 1999, p. 151). Conversion from laparoscopic to open procedure in colorectal surgery is reported with a widely variable rate (5.2 to 77%) (Gervaz et al, 2001, p. 827). Safety is paramount in surgery, and rather than performing complex procedures without adequate training and proctoring, surgeons should answer the question “Would the patient’s outcome have changed if the operation had been planned primarily as an open case?” In addition, when informing the patient about the procedure, a failed laparoscopic attempt should be presented not simply as a drawback, but as a complication, in case the conversion is associated with a poorer postoperative outcome (Yamamoto, Fukunaga, Miyajima, Okuda, Konishi, Watanabe, 2009, p. 383).

In the first study (Celentano et al, 2015, p. 1603) we evaluated the available evidence to establish if laparoscopic surgery could be safely performed even in the complex cases of reversal of Hartmann’s procedure. This procedure was specifically chosen as it has been associated with significant technical challenges in view of the previous sepsis, the high rate of postoperative complications, and the high likelihood of severe intra-abdominal adhesions. Our evaluation was based on critical appraisal and systematic review of 13 studies and a total of 862 patients: 403 undergoing laparoscopic Hartmann's reversal LHR (46.75 %) and 459 open Hartmann's reversal OHR (53.25 %). Not surprisingly there was a high reported rate of conversion to open surgery, which occurred in 65 patients (mean16.1%, range 0–50%). Interestingly, LHR was associated with a reduced overall postoperative 30-day morbidity compared to OHR as reported in all the included studies (OR, 0.24; 95 % CI, 0.17 to 0.34) with no heterogeneity (Q=12.44, p=0.40). The same advantage of LHR was confirmed in the reported rates of postoperative wound and chest infections, confirming that laparoscopic surgery should be attempted even in these difficult cases. Our second systematic review investigated the postoperative outcomes of patients who underwent a planned open procedure POS compared to patients who had an open procedure as a result of a failed laparoscopic approach. (Giglio et al, 2015, p. 1445). In this systematic review we searched Medline, SCOPUS, and Web of Science with no language, publication date or publication status restrictions ensuring as a wide inclusion criteria as possible. To be considered eligible, a study had to report data on perioperative outcomes in patients undergoing planned open surgery (POS group) and in patients in whom the laparoscopic procedure was abandoned and converted to open surgery (COS group). Studies including patients undergoing emergency colorectal resections were excluded.

The search provided a total of 4617 citations. After exclusion of duplicates and of studies that did not meet the inclusion criteria, 79 full text articles were examined in more detail.

We finally included 20 studies and a total of 41,741patients: 30,656 patients underwent POS, while 11,085 patients had an LCR, with 1935 converted to an open procedure. The mean conversion rate was 17% ranging from 7 to 46%. Conversion to open surgery was associated with a higher incidence of postoperative pneumonia and wound infections highlighting the need for these procedures to be performed only in units where dedicated expertise is available.

Self-taught surgery is considered to be unacceptable and dedicated training programmes in colorectal surgery have demonstrated safety and efficacy, while shortening the learning curve, as demonstrated in the third study (Celentano et al, 2015, p. 639) which included

151 patients undergoing advanced laparoscopic surgery for Crohn's disease and Ulcerative colitis. Seventy-seven patients (50.9 %) were operated by supervised trainees and 74 (49%) by recognised surgical trainers. Preoperative characteristics were comparable in the two groups and there were no differences in the postoperative outcomes, apart from an increase in the operating time of approximately 30 minutes when the surgery was performed by a supervised surgical trainee. This study concluded that complex laparoscopic surgery could be safely performed by surgeons in training, provided they are supervised by certified trainers, but also acknowledged that additional operating time is needed for the training of the surgeon.

Time is needed for training, and this must be taken into account when scheduling the operating list. To demonstrate even further the safety and feasibility of the laparoscopic approach, we investigated if patients who had traditionally been denied a minimally invasive approach, such as patients who had many previous open surgeries, could benefit from the laparoscopic approach. Therefore we studied the postoperative outcomes of laparoscopic surgery in patients with Crohn's disease recurrence and who had undergone many previous open surgery for sepsis and recurrence (Celentano et al, 2019, p. 42). These patients in many surgical units would be only offered traditional open surgery, in view of the perceived risks of a failed laparoscopic approach and the limited technical expertise. We found that even in these hostile cases, laparoscopic surgery could be performed with postoperative outcomes at least comparable to open surgery. Even in this setting laparoscopy comes with the price of increased operating time, with approximately 30 extra minutes required, that should be considered in the cost analysis against the benefits of laparoscopic surgery for patients.

Given these results, it would seem easy to conclude that laparoscopic surgery should always be attempted irrespective of the complexity of the procedure, and that time should be spent training surgeons in view of the several advantages of the minimally invasive approach. However, since the introduction of the European Working Time Directive (EWTD), trainees have less time available for training and the number of procedures they have been exposed to has gradually reduced over the last few years with many trainees reporting a reduced number of performed procedures compared to the requirements for certification of completion of training (Varley, Keir, Fagg, 2006, p. 6).

This reported gap between trainees' expectations and limited availability of time for dedicated training needs to be overcome by new training paradigms. Surgical simulation is certainly a successful strategy to maximise learning outside of the surgical theatre, as discussed in my leading article on need for simulation in laparoscopic colorectal surgery training (Celentano, 2015, p. 185), which identified how different methodologies, ranging from simple box trainers for individual training in technical steps of the procedure to advanced cadaveric models able to reproduce team dynamics and real world pressures able to enhance trainees situational awareness and communication skills.

Chapter summary and limitations:

This chapter explored the benefits of minimally invasive surgery, but more importantly the challenges for surgeons in training and educators. Knowledge of the obstacles to be overcome for safe training of the next generation of surgeons is essential in order not to maximise efficient introduction of new technologies without compromising patient safety and is explored further in the following chapter.

Chapter 3. Distance learning in surgery

In Chapter 3 the following manuscripts are discussed:

1. Training value of laparoscopic colorectal videos on the World Wide Web: a pilot study on the educational quality of laparoscopic right hemicolectomy videos.
   Celentano V, Browning M, Hitchins C, Giglio MC, Coleman MG.
   Surg Endosc. 2017 Nov;31(11):4496-4504.

   I was the first and corresponding author of this manuscript. My contribution included study design, data collection and analysis, draft manuscript review, manuscript submission.

2. Lack of online video educational resources for open colorectal surgery training.
   Celentano V, Pellino G, Coleman MG.
   ANZ J Surg. 2019 Mar;89(3):180-183.

   I was the first and corresponding author of this manuscript. My contribution included study design, data collection and analysis, draft manuscript review, manuscript submission.

3. Use of laparoscopic videos amongst surgical trainees in the United Kingdom.
   Celentano V, Smart N, Cahill RA, McGrath JS, Gupta S, Griffith JP, Acheson AG, Cecil TD, Coleman MG.
   Surgeon. 2018 Nov 9. pii: S1479-666X(18)30123-9.

   I was the first and corresponding author of this manuscript. My contribution included study design, data collection and analysis, draft manuscript review, manuscript submission.

Chapter 2 highlighted how dedicated training pathways for minimally invasive surgery are mandatory to maintain patients' safety and to reduce the length of the learning curve

(Thinggard, 2017, p. 5335). There is an increasing demand for modern surgeons to be proficient in practising minimal access surgery (Awad et al, 2018, p. 137), despite this being quite complex and the amount of time trainers and trainees have scheduled for dedicated training being unfortunately limited.

Training in the operating theatre can often be “opportunistic” and dependent upon a mixture of coincidences such as enough time for the case to be performed by the trainee under supervision, presence of a trainer with sufficient expertise in teaching this particular procedure or allocated trainee with the required basic skillset to perform the operation (Gallagher et al, 2018, p. 412). As the healthcare system is often under pressure with limited resources, these circumstances rarely align and therefore the efficiency of training can be jeopardised. Unsurprisingly, trainees in dedicated general surgery programs have reported a reduced number of procedures performed under supervision, with difficulties in achieving the required numbers for certification of training. Therefore, there is a need to better tailor the training episode to the specific needs of the trainee.

One emerging strategy is to identify opportunities allowing for part of the training to take place remotely, away from the limitations of the operating room (Balafoutas et al, 2019, p. 23). The challenges described in Chapter 2 evolved my research towards evaluating the role of distance learning in surgery, with particular reference to the use of video-recordings for constructive feedback and review of surgical performance. As discussed, the advent of laparoscopic surgery revolutionised the training paradigm, requiring introduction of new teaching methods to face the challenges of reduced tactile feedback and prolonged learning curve, without compromising patients’ outcomes. Laparoscopic surgery platforms are equipped with video-recording software and therefore surgeons can record and replay the procedures they perform, setting the scene for self-appraisal and constructive peer review to improve performance and maintain standards.

After establishing the need for distance learning, the first step I took in studying the role of video-based learning in surgery, was to evaluate the availability, effectiveness and quality of video resources already available online and what educational content they offered to viewers. This resulted in a pilot study (Celentano et al, 2017, p. 4496) assessing 31 websites including more than 200 online surgical videos demonstrating a laparoscopic right hemicolectomy.

In this study, we faced the challenge of searching for scientific content on resources not specifically designed for this purpose, shifting from medical databases commonly used for systematic reviews, to websites designed for video sharing. To overcome this difficulty we surveyed a group of trainees on how they used online surgical videos, in order to be able to replicate it with our search strategy in order to be more likely to reproduce how surgical trainees search for video educational material.

Analysis of the data revealed several limitations to the content included. In fact, we reported that an increasing number of videos were published over the last years, but the quality of the educational content presented was quite scarce and variable. A concerning heterogeneity was demonstrated in the safety of the procedures performed, which was scored according to the validated Laparoscopic Competence Assessment Tool (LCAT) (Mackenzie et al, 2015, p. 991; Miskovic et al, 2013, p. 476), with the majority of videos being published without undergoing a peer review process. Less than 25% of the videos explained the details of the patients having the surgery and only 5 to 10% of the videos reported the outcomes of the surgery

Our study concluded that there are a plethora of videos online that surgical trainees can access if interested in enhancing their training in laparoscopic surgery, but unfortunately there is no guidance currently on what the preferred sources should be and if the presented content is suitable for the specific training needs. Before being able to move to the next step of my research, I wanted to broadly understand the availability of online video resources for colorectal surgery training, and therefore repeat this same evaluation of online resources not only for laparoscopic colorectal videos, but also for open surgery videos with a subsequent peer reviewed publication detailing the findings (Celentano et al, 2019, p. 180), obtaining similar results, apart from the expected generalised lack of online open surgery videos due to the known technical challenges with video recording in open surgery as current methodologies used to record and render the surgeon's point of view in open operative surgery remain limited (Saun, Zuo, Grantcharov, 2019, p. 599). Both studies demonstrated that a significant number of published surgical videos do not undergo a formal peer review process, potentially leading to a lack of standardisation of published material.

Having assessed the availability and quality of online training videos, I needed to address the question on the validity of video-based learning in surgery evaluating how users are watching online surgical videos. Being the focus of my research the identification of strategies to maximise training opportunities and reducing the length of the learning curve, the users were clearly identified with the surgical trainees (opportunistic sample).

To facilitate this, I organised and distributed to surgical trainees enrolled in recognised UK training programs, a survey evaluating the interest of trainees for online surgical videos, what resources trainees use and what expectations do they have when watching an online surgical video (Celentano et al, 2018, p. 1479). Unsurprisingly, the results of that survey indicated that surgical trainees in the UK are interested in online surgical videos as 86.7% of the interviewed trainees routinely watched online laparoscopic surgical videos, and they preferred open access platforms, rather than websites requiring subscription fees, as the most frequently accessed websites were YouTube (http://www.youtube.com) and Websurg (http://www.websurg.com).

Moreover, trainees valued surgical videos presenting additional educational content, as they are interested in videos showing not only surgical details such as the position of the patient and instrumentation such as trocars (100%), but also the indication for surgery (96%), pre-operative data (body mass index 92%, previous surgical history 98.7%) and post-operative outcomes (length of hospital stay 80%, 30-day morbidity 94.6%). Interestingly, our study also highlighted the discrepancy between trainees' expectations for surgical videos content and actual available resources, with a significant gap identified.

These findings reinforced the hypothesis that watching a video of a recorded surgical procedure does not necessarily equate to training in surgery, as online resources need to have specific characteristics in order to be categorised as of training value. This raised further research questions, for example:

- Can a surgical video be educational if there is no audio or written narration?

- Can surgeons in training appreciate the validity of the presented technique if no surgical outcomes are presented or if data on the pathology treated is not clearly disclosed?

Chapter summary and limitations:

The same surgical procedure may be appropriate or inadequate on the basis of specific patient’s related factors, such as age, comorbidities or history of previous surgery as for example in rectal cancer surgery, where a more limited transanal procedure, rather than a radical surgery which could be more appropriate in patients with early disease or significant comorbidities (Smart et al, 2016, p. 1069). The publications presented in this chapter highlight the emerging evidence base supporting the role of video-based learning in surgery, largely due to the wide availability of resources and the learner focused approach, but the lack of regulation of this freely available content, potentially demonstrating procedures that are unsafe or inappropriate for educational purposes. Acknowledging the unreliability of many online available resources led to the development of dedicated guidelines which are presented in the following chapter.

Chapter 4. Quality assurance in published surgical videos. Development of multidisciplinary joint trainers-trainees guidelines

In Chapter 4 the following peer-reviewed manuscripts are discussed:

1. Laparoscopic extended right hemicolectomy for hepatic flexure cancer: radical primary vascular approach - a video vignette.
   Celentano V, Coleman MG.
   Colorectal Disease (2016) Jan;18(1):110-1.

   I was the first and corresponding author of this multimedia manuscript. My contribution included study design, data collection, video editing, draft manuscript review, manuscript submission.

2. LAP-VEGaS practice guidelines for reporting of educational videos in laparoscopic surgery: a joint trainers and trainees consensus statement.
   Celentano V, Smart N, McGrath J, Cahill RA, Spinelli A, Obermair A, Hasegawa H, Lal P, Almoudaris AM, Hitchins CR, Pellino G, Browning MG, Ishida T, Luvisetto F, Cingiloglu P, Gash K, Harries R, Harji D, Di Candido F, Cassinotti E, McDermott FD, Berry JEA, Battersby NJ, Platt E, Campain NJ, Keeler BD, Boni L, Gupta S, Griffith JP, Acheson AG, Cecil TD, Coleman MG.
   Ann Surg. 2018 Dec;268(6):920-926.

   I was the first and corresponding author of this multidisciplinary consensus statement. My contribution included study design, data collection and analysis, draft manuscript review, manuscript submission.

Having studied the benefits of minimally invasive colorectal surgery in Chapter 2 and established the heterogeneity of online surgical videos quality in Chapter 3, it became apparent that surgical videos publication needs to be guided towards the development of highly educational content specifically developed for the purpose of training, which will be the focus of this chapter.

In fact, in the previous chapters, we acknowledged the gap between surgical videos viewers' expectations and quality of available online content. Concerningly, there is currently no standard accreditation or regulation for medical videos as training resources. There are self-regulatory expectations and codes of conduct such as The Health on the Net Foundation Code of Conduct (HONCode) which is a code of conduct for medical and health websites, but this applies to all online content and is not specific for audio-visual material. The EQUATOR (Enhancing the QUAlity and Transparency Of health Research) Network (http://www.equator-network.org) lists reporting guidelines which have been developed, mainly driven by the insufficient quality of published reports. Some of these are internationally endorsed guidelines such as the Consolidated Standards of Reporting Trials (CONSORT) (Schulz, Altman, Moher, 2010, p. 834) the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE statement) (von Elm et al, 2008, 0. 344) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, Liberati, Tetzlaff, Altman, 2009, p. 5). Producing surgical videos according to dedicated regulations could result in improving the overall quality of published video outputs, similarly to clinical trials or observational studies developed following the above-mentioned consensus statements.

We have previously discussed how the use of surgical videos as an educational method has expanded rapidly over the last few decades, as advances in the technology required to capture, edit and distribute videos have enabled its widespread use. The andragogical advantages of using videos are many, including the ability to scale instruction to large and small audiences, providing learner-controlled and self-paced learning, facilitating asynchronous learning for professionals with hectic schedules, and the ability to orient the content in realistic and contextually important environments relevant to adult learners. However, the results of the research presented in Chapter 3 confirm that educational videos need to be specifically designed for the particular purpose of surgical training and need to be prepared according to the learners' requirements. In order to demonstrate the educational benefits of annotation of video educational content in a laparoscopic colorectal video, I conducted a study that investigated the use of a surgical video demonstrating a laparoscopic right hemicolectomy, enriched with audio-written commentary, screenshots and diagrams to highlight relevant anatomical structures and presenting surgical outcomes

(Celentano & Coleman, 2016, p. 110). To date this video represents one of the most accessed videos amongst more than 500, on the dedicated video channel of the leading UK and European colorectal disease journal (Celentano & Di Saverio, 2020, p. 241).

The research presented in Chapter 2 and 3 also identified a lack of a standardised protocol for educational video recording, production and online sharing, which required further investigation, and because of the absence of previously published evidence on the topic, a Delphi process (Linstone, Turoff, 1975; Varela-Ruiz, Diaz-Bravo, Garcia-Duran, 2012, p. 90) to generate consensus guidelines was utilised. The Delphi methodology represents a valid way of generating agreement amongst a panel of experts when there is lack of published evidence on a particular topic. Participants invited to the Delphi process complete an anonymous survey and implement the rejected statements with suggested corrections, which are subsequently reviewed in order to amend the statements that did not reach a prior threshold required for consensus.

The Delphi methodology was preferred to semi-structured interviews for the ease of data collection and analyses; moreover a phenomenographic methodology might have lacked reproducibility or focused only on participants' own area of expertise (Cossham, 2017, p. 17). In order to develop appropriate reference guidelines for production of educational surgical videos in laparoscopic surgery it was imperative to start from the needs of the users and for this reason surgeons in training were an integral part to the study protocol development. Additionally, the experience of recognised laparoscopic surgery trainers was researched by establishing a steering committee across different countries (UK, Italy, Japan, Australia, India) and involving several surgical specialties such as general, colorectal, hepatobiliary, urology and gynaecology surgery. This multidisciplinary international, joint trainers and trainees group focused on the development of 37 statements addressing the required characteristics for an educational surgical video (Celentano et al, 2018, p. 920). These were summarised in 7 different domains, such as: Author information and video introduction, case presentation, demonstration of the surgical procedure, outcomes of the procedure, associated educational content, peer review of surgical videos, use of surgical videos in educational curricula.

This multidisciplinary work generated the Laparoscopic Video Educational Guidelines (LAP-VEGaS), a consensus statement for video reporting in laparoscopic surgery. This LAP-VEGaS consensus statement serves as a first step toward building a meaningful conceptual framework for the creation of educational videos for laparoscopic surgery.

Chapter summary and limitations:

It is hoped, the LAP-VEGaS guidelines could provide a basic framework that standardises and facilitates video content evaluation when peer- reviewing videos submitted for publication or presentation, despite recognising that the cognitive load of the procedure presented is only one of several key elements in video-based learning in surgery. Teamwork and communication are paramount for safe and effective performance and have not been explored in this video assessment tool, which focus on surgeon's technical skills. An additional limitation of the LAP-VEGaS guidelines is that they may not apply to all educational surgical videos, such for instance basic skills training or videos demonstrating a single step of a procedure, which may not need such extensive clinical detail.

Reporting guidelines are facilitators of good research and their use is indirectly influencing the quality of future research, as being open about the study shortcomings when reporting one study can influence the conduct of the next study. Constructive criticism based on the LAP-VEGaS video assessment tool could ensure the credibility of the source and the safety of the procedure presented, with an expected resultant improvement in the quality of the educational videos available on the World Wide Web. Validation work is required to understand if exposure of surgical trainees to high quality educational videos prepared according to the LAP-VEGaS checklist, would eventually result in enhanced learning experience and shortened learning curve.

Chapter 5. Hybrid training in minimally invasive colorectal surgery. A pilot study

In Chapter 5 the following manuscript is discussed:

1. Stepwise training in laparoscopic surgery for complex ileocolonic Crohn's disease: analysis of 127 training episodes.
   Celentano V, Flashman K.
   J Surg Educ. 2019 Sep-Oct;76(5):1364-1369
   I was the first and corresponding author of this manuscript. My contribution included study design, data collection and analysis, draft manuscript review, manuscript submission.

In Chapter 2, we identified the challenges for surgical training in minimally invasive colorectal surgery and in Chapter 3 investigated the available resources for shortening the learning curve including the role of distance learning, with a wide variation found in the quality of online educational content with need for standardisation. The opportunity and value of a standardised framework for educational surgical video reporting was researched and presented in Chapter 4 including introducing the LAP-VEGaS guidelines, as a standardised tool for reporting educational videos in laparoscopic surgery. These guidelines were specifically designed as multispecialty and joint trainers and trainees' project, with the intention to make the consensus statements applicable and relevant for the purpose of surgical training in daily practice. However, it remains to be demonstrated if the production and dissemination of high-quality videos eventually translates in better training opportunities for surgical trainees, which is the focus of the research presented in this chapter.

Therefore, I identified the need to investigate the model of hybrid surgical training (Celentano & Flashman, 2019, p. 1364), which collates distance learning in surgery combined with hands on training in theatre. In view of my interest for inflammatory bowel disease (IBD), a specific group of conditions which often require complex surgery, I decided to study the role of hybrid training in these surgical procedures.

Crohn's disease is a chronic inflammatory condition that can involve any part of the gastrointestinal tract and typically affects young adults (Yamamoto, Watanabe, 2014, p. 78). Complications such as perforation, abscess or fistula formation, and obstruction typically require surgical treatment (Toh et al, 2016, p. 8892). In view of the chronic and relapsing nature of this condition, unfortunately surgery cannot be considered curative and a significant proportion of patients require multiple surgical interventions during their lifetime (Morar et al, 2015, p. 247). As many of these operations are undertaken in patients who are malnourished or septic, or had previous surgical interventions, the operation can be quite technically challenging, particularly if performed laparoscopically (de Buck et al, 2017, p. 1713). Crohn's disease surgery may prove technically challenging in view of multifocal inflammation as well as the potential for fistulae, abscesses, and large phlegmons which may require additional or unplanned procedures (Fennern et al, 2019, p. 1222). Moreover, the surgeon must be prepared to control a thickened mesentery with an increased risk for intraoperative bleeding, whilst the lack of tactile feedback may limit the identification of occult disease (Taylor et al, 2014, p. 142).

Patients with complex Crohn's disease have traditionally been denied a minimally invasive surgery approach, but in dedicated centres surgery can be offered laparoscopically with comparable if not better results (Celentano et al, 2019, p. 42). These complex surgeries do not represent the ideal training case for junior surgeons and are often performed by surgeons with specific interest and expertise in IBD. However, having established the obstacles encountered by surgical trainees in learning how to safely perform these complex procedures, there is a need to investigate if there may be specific parts of the operation which may be suitable even for less experienced surgeons. Conversely, surgeons in training with more previous exposure to complex colorectal procedures may be able to perform some of the steps of the surgery. My hypothesis was that by subdividing the surgical procedure in different steps or modules of different complexity, a learner tailored approach may be facilitated maximising the training opportunity without compromising patients' safety. The study had the objective to evaluate the efficacy of different models of surgical training in these complex procedures and if the introduction of distance learning training session with review of surgical videos could enhance the training episode.

To evaluate this I designed a qualitative study, in whom the surgical outcomes were evaluated but more importantly it was annotated which steps of the procedures were performed by the surgeons in training, by dividing the procedures performed for Crohn's disease in four different main steps: exposure and access (introduction of the operating trocars and exposure of the operating field), vascular control (dissection of the tissues and control of the main vascular pedicle), bowel mobilisation and resection/anastomosis. Additionally, the tasks of division of adhesions (often the case if patient had previous surgeries) and strictureplasty (Rottoli et al, 2020, p. 711) fashioning (alternative bowel sparing technique to resection) were counted as extra steps if performed. All the included surgeries were operations typically categorised as complex Crohn's disease surgery, such as patients with multiple internal fistulae or recurrent disease. The procedures were all video-recorded and the peer review and feedback on the trainee performance was undertaken with the use of the validated laparoscopic competence assessment tool - LCAT (Miskovic et al, 2013, p. 476; Mackenzie et al, 2015, p. 991).

One hundred and twenty-seven training episodes were included and 86 were performed by trainees (67.7%). Fistula division was the less commonly performed training episode (25%), while mobilisation and anastomosis were performed by the supervised trainee in 90% and 85% of the cases. The adhesiolysis was performed by trainees in 67% of the cases, while access and exposure in 52%. LCAT scores were significantly higher for senior trainees compared to junior trainees. Finally, when a senior surgical trainee was present in theatre up to 87% of the training episodes could be performed by the trainee. These results clearly demonstrated that even in complex laparoscopic surgery there is significant opportunity for training provided that the training episode is adequate to the learner's skills and experience, allowing a high proportion of the training modules to be performed by the trainee, without compromising the postoperative outcomes. The study also utilised video-based learning in surgery, as all procedures were video-recorded and trainees sat together with the trainers to go through the critical steps of the procedure and critically appraise them with the use of a validated questionnaire for debriefing.

Additionally, it became apparent from the data that adjusting the trainees' allocation to the operating list on the basis of the complexity of the operation performed and of the experience of the trainee is a clear strategy to maximise the usefulness of the training episode. Moreover, utilising the video-recording of the procedure for self-appraisal and trainer feedback should be mandatory in every training programme. Consistent review of surgical videos could facilitate understanding of common errors in order to create awareness of potential injury mechanisms by acknowledging error-event patterns.

Following my extensive research in areas relating to surgical training, such as trainees accessibility of learning opportunities, quality of online video resources and patient safety in complex surgery and with leading others to produce guidelines, I have demonstrated that learning complex surgery following the model detailed in this chapter is achievable, safe and effective. The presented training method requires further research studies to enable comparison and evaluation. Future perspectives are discussed further in the final chapter below.

Chapter 6. Conclusions

My research started from the evaluation of the challenges posed by the introduction of laparoscopic surgery and assessing the outcomes of patients undergoing complex colorectal procedures performed laparoscopically. The findings of this preliminary research confirmed the benefits of laparoscopic surgery and therefore highlighted the need for dedicated training pathways, to reduce the long learning curve in minimally invasive surgery. In view of the limited time available in theatre for complex training, my research focused on the role of surgical simulations and video resources to maximise the benefit from the training event. Surgical videos showed favourable characteristics for self-directed learning, time efficiency and constructive feedback. After establishing lack of adequate educational content in majority of online videos, I led a multidisciplinary study group for development of consensus guidelines for reporting of educational videos. The use of videos for trainers' feedback sessions also resulted valuable when applied in a pilot study assessing stepwise training in complex Crohn's disease surgery.

It is very important for surgeons in training to acquire satisfactory experience and skills prior to completion of training and start of independent practice (Elbadrawy, Majoko, Gasson, 2008, p. 474) and several studies have focused on methods to deliver part of the training outside of the operating room. The rationale is that surgical trainees would benefit more from the live operating if all the required basic knowledge and skills were acquired in a skills lab before operating, so that they could focus more on pathological anatomy and surgical technique when live operating (Jokinen, Mikkola, Harkki, 2019, p. 3688). Both trainer boxes and virtual simulators have proven to be beneficial in enhancing surgical education (Vitish-Sharma, Knowles, Patel, 2011, p. 659) and have been incorporated into many curriculums (Burden 2014). However, complex surgical procedures require skills that can only partially be replicated on box trainers. Our research is based on the understanding that the development of every new surgical method comes with a period of acquisition to attain surgical proficiency. This period allows a surgeon to become increasingly familiar with the fine details of minimally invasive surgery, in order to use it successfully and efficiently even in extremely complex cases, this is known as the surgical learning curve (Guend et al, 2017, p. 2820).

So far, the number of procedures required to reach proficiency in laparoscopic surgery has not been defined clearly (Dagash, Chowdhury, Pierro, 2003, p. 720). Previous studies (Schlachta et al, 2003, p. 1288) demonstrated a reduction in conversion rates with increasing team experience and highlights that the learning curve can be quite prolonged, with improvement noticeable even after several years. Similar learning curves have also been reported in laparoscopic bariatric surgery (Suter et al, 2003, p. 603) and urology (Gaston, Moore, Pruthi, 2004, p. 63). However, such results should be interpreted with some caution, as with increasing experience, surgeons tend to undertake more challenging cases, introducing a case selection bias. Moreover, the learning curve may differ on the basis of the hospital setting and previous surgeons experience (Tsai, Kiu, Huang, Wu, Chang, 2016, p. 34).

Previous research has highlighted the limited number of minimally invasive surgery procedures performed by surgeons in training, due to time constraints, but not uncommonly to lack of experience of the senior surgeon performing the procedure (Shah, Jospeh, Haray, 2005, p. 537).

The research programme on video-based learning in surgery presented in this thesis has some limitations. Firstly, the proposed checklist for video editing and annotation is complex, with 37 recommended items to include, which not only makes it time consuming to follow, but also does not take into account that some items are not applicable for specific procedures, such as videos demonstrating a single, simple surgical task, or educational surgical videos demonstrating a surgical procedure performed at the simulator or using laparoscopic box trainers. Secondly, the body of research presented in this thesis acknowledged that lack of protected training time for trainers and trainees represents one of the main constraints for the acquisition of advanced laparoscopic surgery skills. Nevertheless, the LAP-VEGaS guidelines and the hybrid training model presented in chapter 5 add even more complexity to the production of audio-visual educational content, increasing the time needed for the training episode. Moreover, no direct or indirect cost-analysis was included when evaluating the hybrid training model, which could significantly limit its applicability by other institutions. Thirdly, the effectiveness of the hybrid training model, which combines modular training in theatre with video-based learning and peer feedback needs to be further evaluated with the introduction of a control group, with trainees randomly allocated to the hybrid training pathway. Finally, there are many different strategies to maximise training opportunities and video-based learning only satisfies some of the requirements for the proficiency gain in surgery. Surgeons are part of multidisciplinary teams and communication and teamwork are paramount, and unfortunately have not been fully evaluated in this thesis.

Acknowledging these limitations will help guiding the next steps of my research programme in the field of surgical training, focused at integrating video-based learning with other training modalities and at extending the applicability of the proposed training framework to other disciplines and technologies, such as for example robotic assisted surgery and endoscopy. It is important to consider that surgical technical skills needs to be integrated with team-working, knowledge, communication and several other factors that contribute to successful surgical outcomes. The decision making on when to operate and on when to perform an anastomosis or to fashion a stoma, requires experience and complex decision making, which is not limited to the technical skills of performing it, but more importantly by the ability of taking into account several patients related factors. E-modules and video training are extremely valuable educational methods, however their use its not exclusive and only effective if integrated within a structured training program, including simulation training, dry and wet lab activity. Moreover, proctoring plays an essential role in guaranteeing patients’ safety when operations are performed during the initial part of the surgeons’ learning and proficiency curve. All the training strategies discussed in these thesis are to be integrated and in modern surgical training and their use must be tailored accordingly to the trainee’s background knowledge and experience.

Surgery is evolving continuously thanks to newly developed technologies and innovations for the benefit of our patients. This also means that surgeons need to adapt to these constant changes and ensure safe implementation of these new techniques. This process of lifelong learning significantly benefits from dedicated training modalities, and my research has added to the knowledge base by providing a hybrid model of surgical training, which combines distance learning via the use of surgical videos with tailored training with live operating in theatre. My research means that surgeons in training can more confidently progress throughout their training in complex minimally invasive surgery and that surgical trainers have more guidance on an important additional tool they can use for training the next generation of surgeons. The next challenge for my research programme will be to expand the use of the hybrid training pathway I have applied in the specific field of colorectal surgery, to other surgical specialties. The next steps of my research following the PhD should focus on inter-specialty collaboration in order to promote the model of hybrid surgical training across several surgical specialties and procedures, incorporating training in new technologies such as robotic assisted surgery, or other non-surgical procedures, such as endoscopy.

References.

1. Abdelsattar, J.M., Pandian, T.K., Finnesgard, E.J., El Khatib, M.M., Rowse, P.G., Buckarma, E.N., Gas, B.L., Heller, S.F., Farley, D.R. (2015). Do you see what I see? How we use video as an adjunct to general surgery resident education. *J Surg Educ* Nov-Dec;72(6):e145e50. doi: 10.1016/j.jsurg.2015.07.012.

2. Aggarwal, R., Ward, J., Balasundaram, I., Sains, P., Athanasiou, T., Darzi, A. (2007). Proving the effectiveness of virtual reality simulation for training in laparoscopic surgery. *Ann Surg* 246: 771-779. doi: 10.1097/sla.0b013e3180f61b09

3. Awad, M., Awad, F., Carter, F., Jervis, B., Buzink, S., Foster, J., Jakimowicz, J., Francis, N.K. (2018). Consensus Views on the Optimum Training Curriculum for Advanced Minimally Invasive Surgery: A Delphi Study. *Int J Surg*. May;53:137-142. doi: 10.1016/j.ijsu.2018.03.039.

4. Balafoutas, D., Joukhadar, R., Kiesel, M., Häusler, S., Loeb, S., Woeckel, A., Herr, D. (2019). The Role of Deconstructive Teaching in the Training of Laparoscopy. *JSL*S. Apr-Jun;23(2):e2019.00020. doi: 10.4293/JSLS.2019.00020.

5. Bardakcioglu, O., Khan, A., Aldridge, C., Chen, J. (2013). Growth of laparoscopic colectomy in the United States: analysis of regional and socioeconomic factors over time. *Ann Surg*; 258: 270-274. doi: 10.1097/sla.0b013e31828faa66

6. Bashankaev, B., Baido, S., Wexner, SD. (2011). Review of available methods of simulation training to facilitate surgical education. *Surg Endosc*; 25: 28-35. doi: 10.1007/s00464-0101123-x

7. Bell, R.H., Biester, T.W., Tabuenca, A., Rhodes, R.S., Cofer, J.B., Britt, L.D., Lewis, F.R. (2009). Operative experience of residents in US general surgery programs: a gap between expectation and experience. *Ann Surg* 249:719–724. doi: 10.1097/SLA.0b013e3181a38e59.

8. Benmessaoud, C., Kharrazi, H., MacDorman, K.F. (2011). Facilitators and barriers to adopting robotic-assisted surgery: contextualizing the unified theory of acceptance and use of technology. *PLoS One*. Jan 20;6(1):e16395. doi: 10.1371/journal.pone.0016395.

9. Blencowe, N.S., Parsons, B.A., Hollowood, A.D. (2011). Effects of changing work patterns on general surgical training over the last decade. *Postgrad Med J.* Dec;87(1034):795-9. doi: 10.1136/postgradmedj-2011-130297.

10. Braga, M., Vignali, A., Zuliani, W., Frasson, M., Di Serio, C., Di Carlo, V. (2005) Laparoscopic versus open colorectal surgery: cost-benefit analysis in a single-center randomized trial. *Ann Surg* 242(6):890–895, discussion 895-6. doi: 10.1097/01.sla.0000189573.23744.59.

11. Bridges, M., Diamond, D.L. (1999). The financial impact of teaching surgical residents in the operating room. *Am J Surg* ; 177: 28-32. doi:10.1016/s0002-9610(98)00289-x.

12. Burden, C., Fox, R., Lenguerrand, E., Hinshaw, K., Draycott, T.J., James, M. (2014). Curriculum development for basic gynaecological laparoscopy with comparison of expert trainee opinions; prospective cross-sectional observational study. *Eur J Obstet Gynecol Reprod Biol*. 180:1–7. doi: 10.1016/j.ejogrb.2014.05.036.

13. Celentano, V., Di Saverio, S. (2020). Colorectal disease video channel: free access hub for surgeons, patients and educators. *Colorectal Dis.* Mar;22(3):241-242. doi: 10.1111/codi.15001.

14. Celentano, V., Giglio, M.C., Bucci, L. (2015). Laparoscopic versus open Hartmann's Reversal: a Systematic Review and Meta-analysis. *Int J Colorectal Dis*. Dec;30(12):1603-15. doi: 10.1007/s00384-015-2325-4.

15. Celentano, V., Sagias, F., Flashman, K., Conti, J., Khan, J. (2019). Laparoscopic redo ileocolic resection for Crohn's disease in patients with previous multiple laparotomies. *Scand J Surg*. Mar;108(1):42-48. doi: 10.1177/1457496918772370.

16. Celentano, V. (2015) Need for simulation in laparoscopic colorectal surgery training. *World J Gastrointest Surg*. 27; 7(9):185-9. doi: 10.4240/wjgs.v7.i9.185.

17. Celentano, V., Browning, M., Hitchins, C., Giglio, M.C., Coleman, M.G. (2017). Training value of laparoscopic colorectal videos on the World Wide Web: a pilot study on the educational quality of laparoscopic right hemicolectomy videos. *Surg Endosc*. Nov;31(11):4496-4504. doi: 10.1007/s00464-017-5504-2.

18. Celentano, V., Pellino, G., Coleman, M.G. (2019). Lack of online video educational resources for open colorectal surgery training. *ANZ J Surg*. Mar;89(3):180-183. doi: 10.1111/ans.15077.

19. Celentano, V., Smart, N., Cahill, R.A., McGrath, J.S, Gupta, S., Griffith, J.P., Acheson, A.G., Cecil, T.D., Coleman, M.G. (2018). Use of laparoscopic videos amongst surgical trainees in the United Kingdom. *Surgeon*. Nov 9. pii: S1479-666X(18)30123-9. doi: 10.1016/j.surge.2018.10.004.

20. Celentano, V., Coleman, M.G. (2016). Laparoscopic extended right hemicolectomy for hepatic flexure cancer: radical primary vascular approach - a video vignette. *Colorectal Disease* Jan;18(1):110-1. doi: 10.1111/codi.13156.

21. Celentano, V., Smart, N., McGrath, J., Cahill, R.A., Spinelli, A., Obermair, A., Hasegawa, H., Lal, P., Almoudaris, A.M., Hitchins, C.R, Pellino, G., Browning, M.G, Ishida, T., Luvisetto, F., Cingiloglu, P., Gash, K., Harries, R., Harji, D., Di Candido, F., Cassinotti, E., McDermott, F.D., Berry, J.E.A., Battersby, N.J., Platt, E., Campain, N.J., Keeler, B.D., Boni, L., Gupta, S., Griffith, J.P., Acheson, A.G., Cecil, T.D., Coleman, M.G. (2018). LAP-VEGaS practice guidelines for reporting of educational videos in laparoscopic surgery: a joint trainers and trainees consensus statement. *Ann Surg*. Dec;268(6):920-926. doi: 10.1097/SLA.0000000000002725.

22. Celentano, V., Flashman, K. (2019). Stepwise training in laparoscopic surgery for complex ileocolonic Crohn's disease: analysis of 127 training episodes. *J Surg Educ*. Sep-Oct;76(5):1364-1369. doi: 10.1016/j.jsurg.2019.03.009.

23. Celentano, V., Finch, D., Forster, L., Robinson, J.M., Griffith, J.P. (2015). Safety of supervised trainee-performed laparoscopic surgery for inflammatory bowel disease. *Int J Colorectal Dis* 30: 639-644. doi: 10.1007/s00384-015-2147-4.

24. Choi, D.H., Jeong, W.K., Lim, S.W., Chung, T.S., Park, J.I., Lim, S.B., Choi, H.S., Nam, B.H., Chang, H.J., Jeong, S.Y. (2009). Learning curves for laparoscopic sigmoidectomy used to manage curable sigmoid colon cancer: single-institute, three-surgeon experience. *Surg Endosc;* 23: 622-628. doi: 10.1007/s00464-0089753-y]

25. Cossham, A. An evaluation of phenomenography. *Library and Information Research*. Volume 41. Number 125:17-31. doi.org/10.29173/lirg755.

26. Curtis, N.J., Foster, J.D., Miskovic, D., Brown, C.S.B., Hewett, P.J., Abbott, S., Hanna, G.B., Stevenson, A.R.L., Francis, N.K. (2020). Association of Surgical Skill Assessment with Clinical Outcomes in Cancer Surgery. *JAMA Surg*. May 6:e201004. doi: 10.1001/jamasurg.2020.1004.

27. Dagash, H., Chowdhury, M., Pierro, A. (2003). When can I be proficient in laparoscopic surgery? A systematic review of the evidence. *J Pediatr Surg* 38:720–4. doi: 10.1016/jpsu.2003.50192.

28. de Buck van Overstraeten, A., Eshuis, E.J., Vermeire, S., Van Assche, G., Ferrante, M., D'Haens, G.R., Ponsioen, C.Y., Belmans, A., Buskens, C.J., Wolthuis, A.M., Bemelman, W.A., D'Hoore, A. (2017). Short- and medium-term outcomes following primary ileocaecal resection for Crohn's disease in two specialist centres. *Br J Surg*. Nov;104(12):1713-1722. doi: 10.1002/bjs.10595.

29. Divo, J.M., Martinez, C.H., Mannino, D.M. (2014). Ageing and the epidemiology of multimorbidity. *Eur Respir J*. Oct; 44(4): 1055–1068. doi: 10.1183/09031936.00059814.

30. Duncan, I., Yarwood-Ross, L., Haigh, C. (2013). YouTube as a source of clinical skills education. *Nurse Educ Today*. 33:1576–1580. doi: 10.1016/j.nedt.2012.12.013.

31. Dutta, S., Gaba, D., Krummel, T.M. (2006). To simulate or not to simulate: what is the question? *Ann Surg*; 243: 301-303. Doi: 10.1097/01.sla.0000200853.69108.6d.

32. Elbadrawy, M., Majoko, F., Gasson, J. (2008). Impact of Calman system and recent reforms on surgical training in gynaecology. *J Obstet Gynaecol*.;28:474–477. doi: 10.1080/01443610802083930.

33. Elsey, E.J., Griffiths, G., Humes, D.J., West, J. (2017). Meta-analysis of operative experiences of general surgery trainees during training. *Br J Surg* Jan;104(1):22-33. doi: 10.1002/bjs.10396.

34. Faiz, O., Warusavitarne, J., Bottle, A., Tekkis, P.P., Darzi, A.W., Kennedy, R.H. (2009). Laparoscopically assisted vs. open elective colonic and rectal resection: a comparison of outcomes in English National Health Service Trusts between 1996 and 2006. *Dis Colon Rectum;* 52: 1695-1704. doi: 10.1007/ dcr.0b013e3181b55254.

35. Fayanju, O.M., Aggarwal, R., Baucom, R.B., Ferrone, C.R., Massaro, D., Terhune, K.P. (2017). Surgical Education and Health Care Reform: Defining the Role and Value of Trainees in an Evolving Medical Landscape. *Ann Surg*. Mar;265(3):459-460. doi: 10.1097/SLA.0000000000002021.

36. Fecso, A.B., Bhatti, J.A., Stotland, P.K., Quereshy, A.F., Grantcharov, T.P. (2019). Technical Performance as a Predictor of Clinical Outcomes in Laparoscopic Gastric Cancer Surgery. *Ann Surg*. 2019 Jul;270(1):115-120. doi: 10.1097/SLA.0000000000002741.

37. Fennern, E., Williamson, J., Plietz, M., George, J., Khaitov, S., Greenstein, A.J. (2019). Surgical Techniques and Differences in Postoperative Outcomes for Patients With Crohn's Disease With Ileosigmoid Fistulas: A Single-Institution Experience, 2010-2016. *Dis Colon Rectum*. 2019 Oct;62(10):1222-1230. doi: 10.1097/DCR.0000000000001451.

38. Franklin, M.E. Jr, Rosenthal, D., Abrego-Medina, D., Dorman, J.P., Glass, J.L., Norem, R., Diaz, A. (1996). Prospective comparison of open vs. laparoscopic colon surgery for carcinoma. Five-year results. *Dis Colon Rectum* 39(10 Suppl): S35–S46. doi: 10.1007/BF02053804.

39. Gallagher, A.G., Henn, P.J., Neary, P.C., Senagore, A.J., Marcello, P.W., Bunting, B.P., Seymour, N.E., Satava, R.M. (2918). Outlier experienced surgeon's performances impact on benchmark for technical surgical skills training. *ANZ J Surg*. May;88(5):E412-E417. doi: 10.1111/ans.14474.

40. Gaston, K.E., Moore, D.T., Pruthi, R.S. (2004). Hand-assisted laparoscopic nephrectomy: prospective evaluation of the learning curve. *J Urol;*171:63–7. doi: 10.1097/01.ju.0000099400.50350.9b.

41. Gervaz, P., Pikarsky, A., Utech, M., Secic, M., Efron, J., Belin, B., Jain, A., Wexner, S. (2001). Converted laparoscopic colorectal surgery. *Surg Endosc* 15:827–832. doi:10.1007/s004640080062.

42. Giglio, M.C., Celentano, V., Tarquini, R., Luglio, G., De Palma, G.D., Bucci, L. (2015). Conversion during laparoscopic colorectal resections: a complication or a drawback? A systematic review and meta-analysis of short-term outcomes. *Int J Colorectal Dis*. Nov; 30(11): 1445-55. doi: 10.1007/s00384-015-2324-5.

43. Greensmith, M., Cho, J., Hargest, R. (2016). Changes in surgical training opportunities in Britain and South Africa. *Int J Surg*. 2016;25:76–81. doi: 10.1016/j.ijsu.2015.11.052.

44. Guend, H., Widmar, M., Patel, S., Nash, G.M., Paty, P.B., Guillem, J.G., Temple L,K., Garcia-Aguilar, J., Weiser, M.R. (2017). Developing a robotic colorectal cancer surgery program: understanding institutional and individual learning curves. *Surg Endosc*. Jul;31(7):2820-2828. doi: 10.1007/s00464-016-5292-0.

45. Gurusamy, K.S., Aggarwal, R., Palanivelu, L., Davidson, B.R. (2009). Virtual reality training for surgical trainees in laparoscopic surgery. *Cochrane Database Syst Rev* 2009; Jan 21;(1):CD006575. doi: 10.1002/14651858.CD006575.pub2.

46. Hall, J.C. (2002). Imagery practice and the development of surgical skills. *Am J Surg* 184:465–470. doi: 10.1016/s0002-9610(02)01007-3.

47. Halsted, W.S. (1904). The training of the surgeon. *Bull. Johns Hop. Hosp*. XV, 267–275.

48. Hewett, P.J., Allardyce, R.A., Bagshaw, P.F., Frampton, C.M., Frizelle, F.A., Rieger, N.A., Smith, J.S., Solomon, M.J., Stephens, J.H., Stevenson, A.R. (2008). Short-term outcomes of the Australasian randomized clinical study comparing laparoscopic and conventional open surgical treatments for colon cancer: the ALCCaS trial. *Ann Surg* 248: 728-738. doi: 10.1097/sla.0b013e31818b7595.

49. Jokinen, E., Mikkola, T., Härkki, P. (2019). Effect of structural training on surgical outcomes of residents' first operative laparoscopy: a randomized controlled trial. *Surg Endosc*. Nov;33(11):3688-3695. doi: 10.1007/s00464-018-06657-y.

50. Loukas, C. (2018). Video Content Analysis of Surgical Procedures. *Surg Endosc*. Feb;32(2):553-568. doi: 10.1007/s00464-017-5878-1.

51. Louridas, M., Bonrath, E.M., Sinclair, D.A., Dedy, N.J., Grantcharov, T.P. (2015). Randomized clinical trial to evaluate mental practice in enhancing advanced laparoscopic surgical performance. *Br J Surg*.;102:37–44. doi: 10.1002/bjs.9657.

52. Jamali, R., Soweid, A., Dimassi, H., Bailey, C., Leroy, J., Marescaux, J. (2008). Evaluating the degree of difficulty of laparoscopic colorectal surgery. *Arch Surg* 143(8): 762–767. doi: 10.1001/archsurg.143.8.762.

53. Kemp, J.A., Finlayson, S.R. (2008). Nationwide trends in laparoscopic colectomy from 2000 to 2004. *Surg Endosc*; 22: 1181-1187. doi: 10.1007/s00464-007-9732-8.

54. Kerr, B., O'Leary, J.P. (1999). The training of the surgeon: Dr. Halsted's greatest legacy. *Am Surg*; 65: 1101-1102.

55. Kim, J., Edwards, E., Bowne, W., Castro, A., Moon, V., Gadangi, P., Ferzli, G. (2007). Medial-to-lateral laparoscopic colon resection: a view beyond the learning curve. *Surg Endosc*; 21: 1503-1507. doi: 10.1007/s00464-006-9085-8.

56. Linstone, H.A., Turoff, M. (1975). The Delphi Method Techniques and Applications. *Reading: Addison-Wesley Publishing Company*. (pp. 160-167).

57. Mackenzie, H., Ni, M., Miskovic, D. Motson, R.W., Gudgeon, M., Khan, Z., Longman, R., Coleman, M.G., Hanna, G.B. (2015). Clinical validity of consultant technical skills assessment in the English National Training Programme for Laparoscopic Colorectal Surgery. *Br J Surg* 102(8):991–7. doi: 10.1002/bjs.9828.

58. Miskovic, D., Ni, M., Wyles, S.M., Tekkis, P., Hanna GB. (2012). Learning curve and case selection in laparoscopic colorectal surgery: systematic review and international multicenter analysis of 4852 cases. *Dis Colon Rectum*. 2012 Dec;55(12):1300-10. doi: 10.1097/DCR.0b013e31826ab4dd.

59. Miskovic, D., Ni, M., Wyles, S.M., Kennedy, R.H., Francis, N.K., Parvaiz, A., Cunningham, C., Rockall, T.A., Gudgeon, M.A., Coleman, M.G., Hanna, G.B. (2013). Is

competency assessment at the specialist level achievable? A study for the national training programme in laparoscopic colorectal surgery in England. *Ann Surg* 257:476–482. doi: 10.1097/SLA.0b013e318275b72a.

60. Miskovic, D., Wyles, S.M., Ni, M., Darzi, A.W., Hanna, G.B. (2010). Systematic review on mentoring and simulation in laparoscopic colorectal surgery. *Ann Surg*; 252: 943-951. doi: 10.1097/sla.0b013e3181f662e5.

61. Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *J Clin* Epidemiol 2009; doi:10.1016/j.jclinepi.2009.06.005

62. Moore, M.J., Bennett, C.L. The Southern Surgeons Club. (1995). The learning curve for laparoscopic cholecystectomy. *Am J Surg*; 170: 55-5. doi: 10.1016/s0002-9610(99)80252-9.

63. Morar, P.S., Faiz, O., Hodgkinson, J.D., Zafar, N., Koysombat, K., Purcell, M., Hart, A., Warusavitarne, J. (2015). Concomitant colonic disease (Montreal L3) and re-resectional surgery are predictors of clinical recurrence following ileocolonic resection for Crohn's disease. *Colorectal Dis*. Nov;17(11):O247-55. doi: 10.1111/codi.13094.

64. Ozyurda, F., Dokmeci, F., Palaoglu, O., Arda, B. (2002). The role of interactive training skills courses in medical education at the Ankara University School of Medicine. *Teach Learn Med* ; 14:189–193. doi: 10.1207/S15328015TLM1403_10.

65. Park, J., MacRae, H., Musselman, L.J., Rossos, P., Hamstra, S.J., Wolman, S., Reznick, R.K. (2007). Randomized controlled trial of virtual reality simulator training: transfer to live patients. *Am J Surg*; 194:205-211. doi: 10.1016/j.amjsurg.2006.11.032.

66. Rottoli, M., Tanzanu, M., Manzo, C.A., Bacchi Reggiani, M.L., Gionchetti, P., Rizzello, F., Boschi, L., Poggioli, G. (2020). Strictureplasty for Crohn's disease of the small bowel in the biologic era: long-term outcomes and risk factors for recurrence. *Tech Coloproctol*. Jul;24(7):711-720. doi: 10.1007/s10151-020-02208-7.

67. Samia, H., Khan, S., Lawrence, J., Delaney, C.P. (2013). Simulation and its role in training. *Clin Colon Rectal Surg*; 26: 47-5. doi: 10.1055/s-0033-1333661.

68. Saun, T.J., Zuo, K.J., Grantcharov, T.P. (2019). Video Technologies for Recording Open Surgery: A Systematic Review. *Surg Innov*. Oct;26(5):599-612. doi: 10.1177/1553350619853099.

69. Schlachta, C.M., Mamazza, J., Gregoire, R., Burpee, S.E., Pace, K.T., Poulin, E.C. (2003). Predicting conversion in laparoscopic colorectal surgery. *Surg Endosc*;17:1288–91. doi: 10.1007/s00464-002-8920-9.

70. Scott, D.J., Bergen, P.C., Rege, R.V., Laycock, R., Tesfay, S.T., Valentine, R.J., Euhus, D.M., Jeyarajah, D.R., Thompson, W.M., Jones, D.B. (2000). Laparoscopic training on bench models: better and more cost effective than operating room experience? *J Am Coll Surg*; 191: 272-283. doi: 10.1016/s1072-7515(00)00339-2.

71. Scott, D.J., Young, W.N., Tesfay, S.T., Frawley, W.H., Rege, R.V., Jones, D.B. (2001). Laparoscopic skills training. *Am J Surg*; 182: 137-142. doi: 10.1016/s0002-9610(01)00669-9.

72. Schwandner, O., Schiedeck, T.H., Bruch, H. (1999). The role of conversion in laparoscopic colorectal surgery: do predictive factors exist? *Surg Endosc* 13:151–156. doi: 10.1007/s004649900927.

73. Schulz, K.F., Altman, D.G., Moher, D., for the CONSORT Group. (2010). CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. *J Clin Epi* ; 63(8):834-840. doi: 10.1016/j.jclinepi.2010.02.005.

74. Shah, P.R., Joseph, A., Haray, P.N. (2005). Laparoscopic colorectal surgery: learning curve and training implications. *Postgrad Med J*. Aug;81(958):537-40. doi: 10.1136/pgmj.2004.028100.

75. Smart, C.J., Korsgen, S., Hill, J., Speake, D., Levy, B., Steward, M., Geh, J.I., Robinson, J., Sebag-Montefiore, D., Bach, S.P. (2016). Multicentre study of short-course radiotherapy and transanal endoscopic microsurgery for early rectal cancer. *Br J Surg*. 2016 Jul;103(8):1069-75. doi: 10.1002/bjs.10171.

76. Smith, C.D., Farrell, T.M., McNatt, S.S., Metreveli, R.E. (2001). Assessing laparoscopic manipulative skills. *Am J Surg* 2001; 181: 547-550. doi: 10.1016/s0002-9610(01)00639-0.

77. Stein, S., Stulberg, J., Champagne, B. (2012). Learning laparoscopic colectomy during colorectal residency: what does it take and how are we doing? *Surg Endosc* 2012; 26: 488-492. doi: 10.1007/s00464-011-1906-8.

78. Suter, M., Giusti, V., Heraief, E., Zysset, F., Calmes, J.M. (2003). Laparoscopic Roux-en-Y gastric bypass: initial 2-year experience. *Surg Endosc*;17:603–9. doi: 10.1007/s00464-002-8952-1.

79. Taylor, S., Mallett, S., Bhatnagar, G., Bloom, S., Gupta, A., Halligan, S., Hamlin, J., Hart, A., Higginson, A., Jacobs, I., McCartney, S., Morris, S., Muirhead, N., Murray, C., Punwani, S., Rodriguez-Justo, M., Slater, A., Travis, S., Tolan, D., Windsor, A., Wylie, P., Zealley, I. (2014). METRIC (MREnterography or ulTRasound in Crohn's disease): a study protocol for a multicentre, non-randomised, single-arm, prospective comparison study of magnetic resonance enterography and small bowel ultrasound compared to a reference standard in those aged 16 and over. *BMC Gastroenterol*. 2014 Aug 11;14:142. doi: 10.1186/1471-230X-14-142.

80. Tekkis, P.P., Senagore, A.J., Delaney, C.P., Fazio, V.W. (2005). Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. *Ann Surg* ; 242: 83-91. doi: 10.1097/01.sla.0000167857.14690.68.

81. Thinggaard, E. (2017). Take-Home Training in Laparoscopy. *Dan Med J* 2017 Apr;64(4):B5335.

82. The Southern Surgeons Club. (1991). A prospective analysis of 1518 laparoscopic cholecystectomies. *N Engl J Med;* 324: 1073-1078. doi: 10.1056/nejm199104183241601.

83. Toh, J.W., Stewart, P., Rickard, M.J., Leong, R., Wang, N., Young, C.J. (2016). Indications and surgical options for small bowel, large bowel and perianal Crohn's disease. *World J Gastroenterol*. 2016 Oct 28;22(40):8892-8904. doi: 10.3748/wjg.v22.i40.8892.

84. Tsai, K.Y., Kiu, K.T., Huang, M.T., Wu, C.H., Chang, T.C. (2016). The learning curve for laparoscopic colectomy in colorectal cancer at a new regional hospital. *Asian J Surg*. Jan;39(1):34-40. doi: 10.1016/j.asjsur.2015.03.008.

85. Varley, I., Keir, J., Fagg, P. (2006). Changes in caseload and the potential impact on surgical training: a retrospective review of one hospital's experience. *BMC Med Educ* 2006;6:6. doi: 10.1186/1472-6920-6-6.

86. Varela-Ruiz, M., Díaz-Bravo, L., García-Durán, R. (2012). Description and uses of the Delphi method for research in the healthcare area. *Inv Ed Med*. 2012;1(2):90–5.

87. Vitish-Sharma, P., Knowles, J., Patel, B. (2011). Acquisition of fundamental laparoscopic skills: is a box really as good as a virtual reality trainer? *Int J Surg*. 2011;9:659–661. doi: 10.1016/j.ijsu.2011.08.009.

88. von Elm, E., Altman, D.G., Egger, M., Pocock, S.J., Gøtzsche, P.C., Vandenbroucke, J.P.; STROBE Initiative. (2008). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin Epidemiol*. 2008 Apr;61(4):344-9. doi: 10.1016/j.jclinepi.2007.11.008.

89. Yamamoto, T., Watanabe, T. (2014). Surgery for luminal Crohn's disease. *World J Gastroenterol*. Jan 7;20(1):78-90. doi: 10.3748/wjg.v20.i1.78.

90. Yamamoto, S., Fukunaga, M., Miyajima, N., Okuda, J., Konishi, F., Watanabe, M. (2009). Impact of conversion on surgical outcomes after laparoscopic operation for rectal carcinoma: a retrospective study of 1,073 patients. *J Am Coll Surg* 208:383–389. doi:10. 1016/j.jamcollsurg.2008.12.002

Appendix 1. Set of all publications on which this thesis is based

Publication n. 1

Celentano, V., Giglio, M.C., Bucci, L. (2015). Laparoscopic versus open Hartmann's Reversal: a Systematic Review and Meta-analysis. *Int J Colorectal Dis*. (2015) Dec;30(12):1603-15.

`

Int J Colorectal Dis
DOI 10.1007/s00384-015-2325-4

REVIEW

Laparoscopic versus open Hartmann's reversal: a systematic review and meta-analysis

Valerio Celentano [1] · Mariano Cesare Giglio [1] · Luigi Bucci [1]

Accepted: 9 July 2015

Abstract

Background Hartmann's reversal is a major surgical procedure with consistent morbidity and mortality rates. Laparoscopy has been extensively applied to colorectal surgery providing significant benefits on short- and long-term outcomes. We performed a meta-analysis of the current evidence comparing the short-term outcomes of laparoscopic Hartmann's reversal (LHR) to open Hartmann's reversal (OHR).

Methods A systematic search of Medline, Scopus, Web of Science, Embase, and the Cochrane database was performed. Comparative studies reporting short-term outcomes of LHR versus OHR with an intention-to-treat analysis were considered for eligibility. Primary outcome was 30-day morbidity. Secondary outcomes were 30-day mortality, 30-day reoperations, length of hospital stay (LOS), operating time, and estimated blood loss.

Results Thirteen studies comparing 862 patients (403 LHR vs 459 OHR) were included. There was no difference in mortality, while LHR was associated with a reduced overall postoperative 30-day morbidity (OR, 0.24; 95 % CI, 0.16 to 0.34). Wound infections (OR, 0.54; 95 % CI, 0.35 to 0.85) and ileus (OR, 0.47; 95 % CI, 0.25 to 0.87) were more common after OHR. LOS was shorter in the laparoscopic group as it was the time to flatus. Meta-regression analysis showed that the results were independent from potential effect modifiers.

Conclusions LHR has less short-term complications than OHR in terms of overall morbidity, wound infection, and postoperative ileus. LOS is shorter in the LHR group, while no significant difference exists in the operating time. Randomized controlled trials are needed to confirm these findings on unbiased populations.

Keywords Hartmann's reversal · Laparoscopic colorectal surgery · Hartmann's procedure

✉ Valerio Celentano
valeriocelentano@yahoo.it

[1] Department of General, Oncologic and Video-Assisted Surgery, Colorectal Unit, Federico II University, Naples, Italy

Introduction

The Hartmann's procedure (HP) consists of a rectosigmoid resection with formation of a proximal terminal colostomy and closure of the rectal stump [1]. HP is designed to avoid the risk of anastomotic complications, and current indications include diverticulitis complicated by peritonitis [2, 3], obstructing or perforated left-sided colonic tumors, and traumatic and ischemic injuries associated with fecal contamination [4].

Hartmann's reversal (HR) restores intestinal continuity and avoids the physical and psychological difficulties associated with a long-term colostomy [5], but unfortunately, this second-stage procedure requires a major abdominal surgery and is a technically challenging operation, with reported morbidity and mortality rates of up to 50 and 7 %, respectively [6–8]. Based on the perceived high risk of postoperative complications, almost half of patients do not have their colostomy closed [9, 10] with reasons for not reversing commonly including age, high-risk status, and patient refusal for fear of postoperative complications [11].

Laparoscopic techniques for colorectal surgery have been evolving since the early 1990s demonstrating benefits over open techniques in terms of shorter hospital length of stay [12], less pain, and quicker return to full activities [13], with

Published online: 19 July 2015

Table 1 Data extracted from the included study

Study-related	First author, country, year of publication, study period, study design
Patient-related	Age, gender, BMI, ASA score, number of previous abdominal operations
HP-related	Indication for the previous HP (benign/ malignant) type of approach (open /laparoscopic), Hinchey classification in case of diverticulitis; time to reversal
HR-related	Surgical approach (open/laparoscopic), conversion rate, operating time, EBL, intraoperative complications, number of protective ileostomies, number of HR attempted but failed, postoperative recovery program
Outcomes	30-day mortality, 30-day reoperation and readmission rate, 30-day complication rate. Anastomotic leak, IAC, bleeding, wound infection, ileus, SBO, cardiovascular and respiratory complications, sepsis, enterocutaneous fistula and stoma-related complications. LOS, time to flatus, time to defecation

BMI body mass index, *ASA* American Society of Anesthesiologist, *HP* Hartmann's procedure, *HR* Hartmann's reversal, *LHR* laparoscopic Hartmann's reversal, *OHR* open Hartmann's reversal, *EBL* estimated blood loss, *IAC* intra-abdominal collection, *SBO* small bowel obstruction, *LOS* length of hospital stay

the first laparoscopic Hartmann's reversal (LHR) being reported in 1993 [14].

LHR could therefore offer reduced morbidity and mortality compared to the conventional open procedure while improving reversal rates. The aims of this study are to systematically investigate the literature and to perform a meta-analysis of the current evidence evaluating the short-term outcomes of LHR compared to open Hartmann's reversal (OHR).

Methods

Data sources and search strategy

After the development of a review protocol in compliance with the MOOSE guidelines for reporting meta-analysis of observational studies [15], a comprehensive literature search of Medline, Scopus, Web of Science, Embase, and the Cochrane Central Register of controlled trials was performed with no language, publication date, or publication status restrictions.

An extensive search was conducted using the search terms: "Hartmann* or *stoma or ostomy or colostom*" and "mini invasive or mini-invasive or minimally invasive or laparoscop* or keyhole" and "reversal or restoration or closure or continuity or reconstruction." The last search was run on December 6th, 2014.

The reference list of the retrieved articles was searched to identify additional eligible studies.

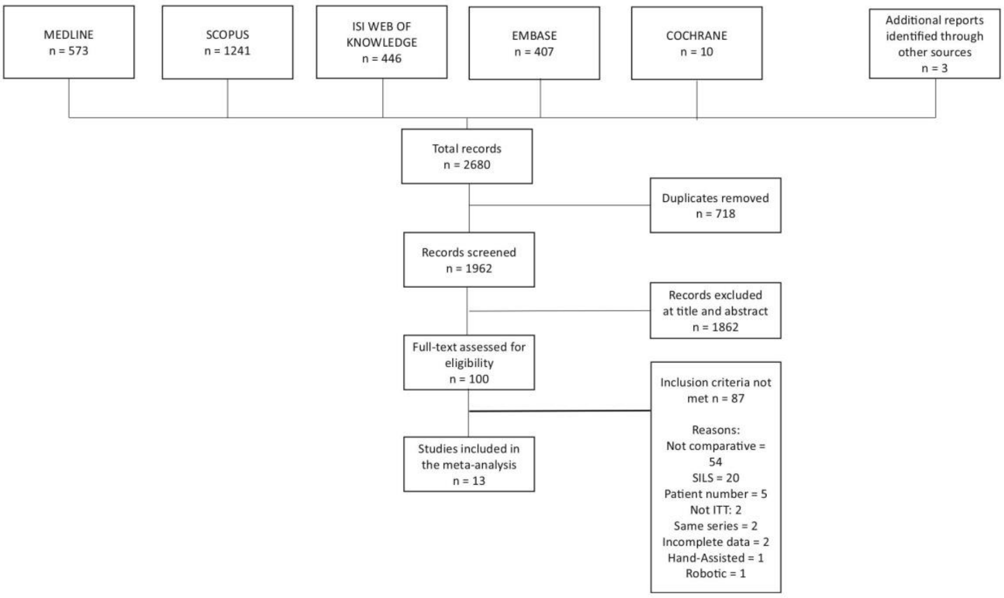


Fig. 1 Search strategy and results. *n* number, *ITT* intention-to-treat analysis, *SILS* single incision laparoscopic surgery

Table 2 Characteristics of the included studies: patient populations

First author	Year	Study period	Patients (n)	Age (years)[a]	Sex (M:F ratio)	BMI (kg/m^2)[a]	ASA≥3 (n (%))	Indication (ben:mal ratio)	TTR (months)[a]	CR (n (%))
Achkasov [27]	2010	2008–2010	LHR: 36	55.7±11.5	19:17	28.6±5.7	NR	13:23	12.7±7.4	0 (0)
			OHR: 35	51.5±13.9	16:19	27.7±4.9	NR	18:17	14.3±8.4	
Chouillard [28]	2009	2002–2007	LHR: 44	58±15.1	19:25	26 (18–38)[b]	5 (11.3)	36:8	5.1	4 (9)
			OHR: 44	55.9±16	19:25	25 (17–41)[b]	6 (13.6)	36:8	6.2	
De Angelis [29]	2013	2000–2010	LHR: 28	54.9±15.4	12:16	24.1±3.1	2 (7.1)	28:0	4.2±2	0 (0)
			OHR: 18	61.4±12.8	5:13	24.8±2.9	2 (11.1)	18:0	4.7±2.1	
Faure [30]	2007	2000–2004	LHR: 14	61 (35–86)[b]	6:8	NR	3 (21.4)	10:4	6 (3–18)[b]	2 (14.2)
			OHR: 20	63 (35–85)[b]	10:10	NR	6 (30)	15:5	4 (4–21)[b]	
Maitra [31]	2013	2003–2011	LHR: 45	59±13.9	26:19	id	id	43:2	NR	13 (28.8)
			OHR: 50	58±15	28:22	id	id	36:14	NR	
Mazeh [32]	2009	1998–2006	LHR: 41	58.49 (33–85)[b]	20:21	26.78 (19.5–40.8)[b]	NR	39:2	4.8 (1.3–31.6)[b]	8 (19.5)
			OHR: 41	63.7 (26–82)[b]	21:20	26.78 (19.5–40.8)[b]	NR	38:3	7.6 (1.4–21.2)[b]	
Ng [33]	2013	2000–2012	LHR: 47	61 (34–84)[c]	NR	NR	NR	16:31	14 (3–79)[c]	13 (27.6)
			OHR: 35	60 (32–90)[c]	NR	NR	NR	15:20	12 (5–45)[c]	
Rosen [34]	2006	1997–2004	LHR: 22	54 (33-73)[b]	9:13	26.2 (19.6–34.4)[b]	14 (63.6)	20:2	5.6 (3–12)[b]	2 (9)
			OHR: 22	49 (20–83)[b]	13:9	27.2 (19.5–43.8)[b]	8 (36.3)	17:5	9.1 (3–24)[b]	
Studer [35]	2014	2006–2011	LHR: 28	62.5±14.3	17:11	24.7±3.7	id	NR	9.4 (5.5)	14 (50)
			OHR: 25	64.3±9.4	10:15	26±7.5	id	NR	11 (9.4)	
Svenningsen [36]	2010	2005–2008	LHR: 21	61 (26–79)[c]	11:10	23 (19–31)[c]	id	18:3	5.9 (2.9–12.8)[c]	1 (4.7)
			OHR: 22	55 (34–79)[c]	10:12	30 (22–35)[c]	id	16:6	8.8 (3.9–29.5)[c]	
Walklett [37]	2014	2007–2012	LHR: 10	NR	NR	NR	NR	NR	NR	2 (20)
			OHR: 37	NR	NR	NR	NR	NR	NR	
Yang [38]	2014	2001–2012	LHR: 43	60.9±14.4	26:17	29.7±6.5	6 (13.9)	38:5	NR	3 (6.9)
			OHR: 64	59.7±17.7	34:30	27.6±6.7	13 (20.3)	46:18	NR	
Zimmermann [39]	2014	2003–2011	LHR: 24	46 (27–84)[c]	14:10	26.5 (19.5–34.9)[c]	9 (37.5)	23:1	5.4 (2.9–7.9) [c]	3 (12.5)
			OHR: 46	60 (18–84)[c]	22:24	25.9 (15.9–35.7)[c]	24 (52.1)	35:11	6.8 (3.8–9.6) [c]	

n number, *M* male, *F* female, *BMI* body mass index, *ASA* American Society of Anesthesiologist, *ben:mal* benignant/malignant ratio, *TTR* lag time to reversal, *CR* conversion rate, *LHR* laparoscopic Hartmann's reversal, *OHR* open Hartmann's reversal, *NR* not reported, *id* incomplete data

Data are expressed as they were reported in the original study as:

[a] Mean±standard deviation

[b] Mean (range)

[c] Median (range)

Table 3 Results of risk of bias assessment

First author	NOS score	Comparability of patients undergoing laparoscopic and open Hartmann's reversal for						
		Age	Sex	BMI	ASA	Time to reversal	Hinchey grade	Disease (ben/mal)
Achaksov [27]	6	Yes	Yes	Yes	NR	Yes	NR	Yes
Chouillard [28]	9	Yes	Yes	Yes	Yes	Yes	NR	Yes
De angelis [29]	8	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Faure [30]	9	Yes	Yes	NR	Yes	Yes	Yes	Yes
Maitra [31]	6	No	Yes	Yes	Yes	Yes	NR	No
Mazeh [32]	7	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ng [33]	8	Yes	Yes	NR	NR	Yes	NR	Yes
Rosen [34]	6	Yes	Yes	Yes	Yes	NR	Yes	Yes
Studer [35]	6	NR	NR	NR	NR	NR	NR	NR
Svenningsen [36]	5	Yes	Yes	Yes	Yes	Yes	NR	No
Walklett [37]	9	Yes	Yes	Yes	Yes	NR	NR	Yes
Yang [38]	8	No	No	No	No	NR	NR	No
Zimmermann [39]	7	Yes	Yes	Yes	Yes	NR	NR	No

NOS Newcastle-Ottawa scale, *BMI* body mass index, *ASA* American Society of Anesthesiologist score, *ben/mal* benign/malignant, *NR* not reported

Table 4 Included study: morbidity and mortality outcomes

First author	Patients (*n*)	Mortality (*n*)	Morbidity (*n* (%))	AL	WI	IAC	BL	Ileus	Resp	Ileostomy (*n* (%))	Reop (*n* (%))
Achkasov [27]	LHR: 36	0	2 (5.6)	0	1	0	0	0	0	3 (8.3)	NR
	OHR: 35	0	3 (8.5)	0	3	0	0	0	0	11 (31.4)	NR
Chouillard [28]	LHR: 44	1	6 (13.6)	0	4	1	0	0	1	2 (4.6)	1 (2.3)
	OHR: 44	0	16 (36.3)	3	6	4	0	0	2	4 (9)	2 (4.6)
De Angelis [29]	LHR: 28	0	1 (3.6)	0	0	0	1	0	0	0 (0)	1 (3.6)
	OHR: 18	0	6 (33.3)	0	6	0	0	0	0	0 (0)	0 (0)
Faure [30]	LHR: 14	0	2 (14.3)	0	1	0	0	0	0	NR	0 (0)
	OHR: 20	0	6 (30)	1	0	0	0	0	0	NR	0 (0)
Maitra [31]	LHR: 45	0	4 (8.9)	0	2	0	0	2	0	NR	0 (0)
	OHR: 50	0	13 (26)	2	2	1	0	3	2	NR	4 (8)
Mazeh [32]	LHR: 41	0	12 (29.2)	0	6	0	0	4	0	NR	0 (0)
	OHR: 41	0	30 (73.2)	0	8	0	0	7	5	NR	2 (4.9)
Ng [33]	LHR: 47	0	10 (21.3)	2	6	1	0	1	0	5 (10.7)	2 (4.3)
	OHR: 35	0	14 (40)	0	8	0	0	6	0	20 (57.1)	1 (2.9)
Rosen [34]	LHR: 22	0	3 (13.7)	0	3	0	0	0	0	NR	0 (0)
	OHR: 22	0	16 (72.8)	1	6	0	1	4	2	NR	0 (0)
Studer [35]	LHR: 28	0	22 (78.6)	0	4	1	1	7	2	NR	NR
	OHR: 25	0	21 (84)	2	8	3	0	7	0	NR	NR
Svenningsen [36]	LHR: 21	0	2 (9.5)	NR	NR	NR	NR	NR	NR	NR	1 (4.8)
	OHR: 22	1	3 (13.7)	NR	NR	NR	NR	NR	NR	NR	0 (0)
Walklett [37]	LHR: 10	0	12 (120)	0	2	0	0	0	1	NR	NR
	OHR: 37	0	37 (100)	1	8	0	0	1	3	NR	NR
Yang [38]	LHR: 43	0	6 (14)	0	2	0	0	1	0	0 (0)	0 (0)
	OHR: 64	0	35 (54.7)	0	1	1	2	0	2	3 (4.7)	0 (0)
Zimmermann [39]	LHR: 24	0	5 (20.9)	0	2	0	0	1	2	NR	0 (0)
	OHR: 46	0	26 (56.5)	2	7	0	1	7	4	NR	7 (15.2)

n number, *AL* anastomotic leak, *WI* wound infection, *IAC* intra-abdominal collection, *BL* bleeding, *Resp* respiratory complications, *Reop* reoperations, *LHR* laparoscopic Hartmann's reversal, *OHR* open Hartmann's reversal, *NR* not reported

Table 5 Included studies: surgical details

First Author	Op time (min)	EBL (ml)	LOS (days)	Tflatus (days)
Achkasov [27]	LHR: 179±65.1	64.7±33.7	9.1±2.7	2.3±0.5
	OHR: 266.9±71.8	181.8±120.4	12.9±3.4	2.7±0.9
Chouillard [28]	LHR: 195±60.7	NR	4.8±2.8	2.1±0.9
	OHR: 160±63.8	NR	6.8±4	3.2±2.2
De Angelis [29]	LHR: 171.1±27.4	225±38.6	6.7±1.9	3±1.3
	OHR: 235.8±43.6	301.1±54.6	11.2±5.1	4.3±1.7
Faure [30]	LHR: 143±37.5	NR	9.5±2.5	4±1.3
	OHR: 180±65	NR	11±8.3	4±3
Maitra [31]	LHR: 164.1±32.8	NR	6.7±0.8	NR
	OHR: 172.9±13.2	NR	14.9±4.4	NR
Mazeh [32]	LHR: 193.1±92.8	166.6±212.5	6.5±3.3	4.2±0.8
	OHR: 209.2±69.5	326.6±225	8.1±4.5	5.3±3.5
Ng [33]	LHR: 178±60.3	180±135	12±3.3	NR
	OHR: 172±63	273±192.5	17±7.3	NR
Rosen [34]	LHR: 158±113	114±55	4.2±3.6	3.5±0.9
	OHR: 189±54.5	270±187.5	7.3±12.3	5±2.2
Studer [35]	LHR: 291±64	248±221	11.6±9	NR
	OHR: 277±91	288±261	15.4±11.9	NR
Svenningsen [36]	LHR: 261±52.5	635±537	6±3	2.5±1
	OHR: 176±60	835±375	8.5±2.5	2.8±1.3
Walklett [37]	LHR: 177±22.5	NR	6±3	NR
	OHR: 235±127.5	NR	8.5±2.5	NR
Yang [38]	LHR: 276±70	NR	6.7±2.6	2.8±0.9
	OHR: 242±78.3	NR	10.8±6.4	4±1.5
Zimmermann [39]	LHR: 183±42.5	NR	9.8±1.8	3±0.5
	OHR: 191±74.7	NR	51±38.8	4.8±1.8

Data are expressed as mean±standard deviation

n number, *Op time* operating time, *min* minutes, *EBL* estimated blood loss, *ml* milliliters, *LOS* length of hospital stay, *Tflatus* time to flatus, *LHR* laparoscopic Hartmann's reversal, *OHR* open Hartmann's reversal, *NR* not reported

Eligibility criteria and study selection

Inclusion criteria were as follows: (1) comparative studies evaluating patients undergoing laparoscopic Hartmann's reversal (LHR) versus open Hartmann's reversal (OHR); (2) HR performed with standardized and well-described methodology; (3) intention-to-treat analysis for the laparoscopic group (all procedures started laparoscopically were included in the LHR group, even if converted); (4) complete follow-up data and losses clearly reported; and (5) studies including at least 10 patients in each group, to minimize the imprecision associated with very small populations.

Studies including only hand-assisted, robotic, and single incision laparoscopic surgery (SILS) patients were excluded. Indexed abstract of posters and podium presentations at international meetings were not included. Reviews were only checked to find further relevant studies, and when the same author and institution published the same case series in different articles, only the most recent paper was evaluated.

Two reviewers (VC and MG) independently assessed the reports for eligibility at title and abstract level. In case of discrepancies, a third author (LB) was consulted and agreement was reached by consensus.

Data extraction, methodological quality appraisal, and risk of bias assessment

Two authors (VC and MG) independently retrieved the data from each included study filling an electronic database with the records detailed in Table 1. For studies that reported insufficient data, the corresponding authors were contacted for further information; if no response was obtained after two reminders, the study was excluded from the review.

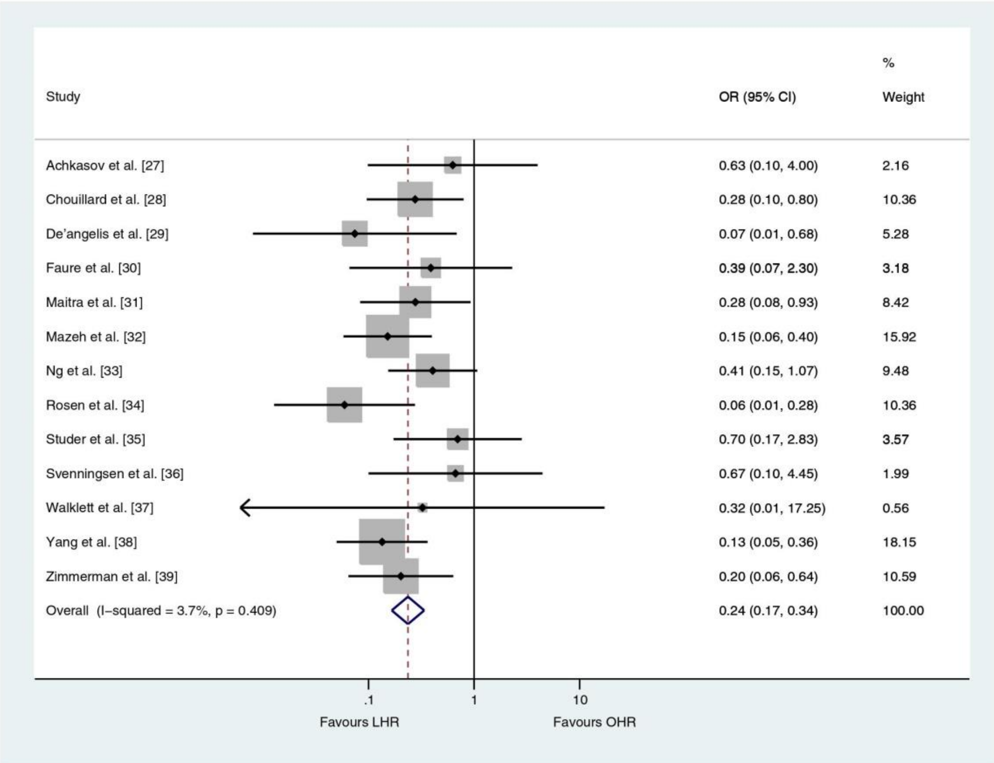


Fig. 2 Forest plot comparing 30-day overall morbidity after laparoscopic Hartmann's reversal (*LHR*) vs open Hartmann's reversal (*OHR*). A fixed-effects model was used for meta-analysis. An odds ratio (*OR*) less than 1 indicates a lower incidence of morbidity in LHR group

The quality of the included studies was evaluated by the Newcastle-Ottawa Scale (NOS) [16]: on a scale of 9, a greater score was considered to be an indicator of better quality. A further assessment of the risk of selection bias was performed considering the balance between the groups for seven variables: age, gender, American Society Anesthesiologist (ASA) score, body mass index (BMI), indication for HP, Hinchey grade at the time of the index resection in case of diverticulitis, and lag time between the HP and the reversal. If the study did not report data about one of these characteristics, this was considered to be not balanced.

Outcome analysis

The primary outcome was 30-day overall morbidity. Secondary outcomes were 30-day mortality and 30-day complication-specific morbidity, 30-day reoperation rate and readmission rate, length of hospital stay (LOS), operating time, estimated blood loss (EBL), time to flatus and conversion rate.

Odds ratio (OR) and 95 % confidence intervals (95 % CI) were used as summary measures for dichotomous outcomes while weighted mean difference (WMD) and 95 % CI were used for continuous outcomes. They were calculated with the fixed-effects Mantel-Hænzel model, while, in case of significant heterogeneity across studies, the random-effects DerSimonian and Laird model was used. The heterogeneity among studies was tested by Q statistic and quantified by I^2 statistic: as a guide, I^2 values <25 % indicated low heterogeneity, 25–50 % moderate, and >50 % high [17]. Missing data were estimated [18] or imputed [19] from the available data. For dichotomous analyses with zero count cells, 0.5 was added to each cell for analysis, while in case the frequency of the event was 0

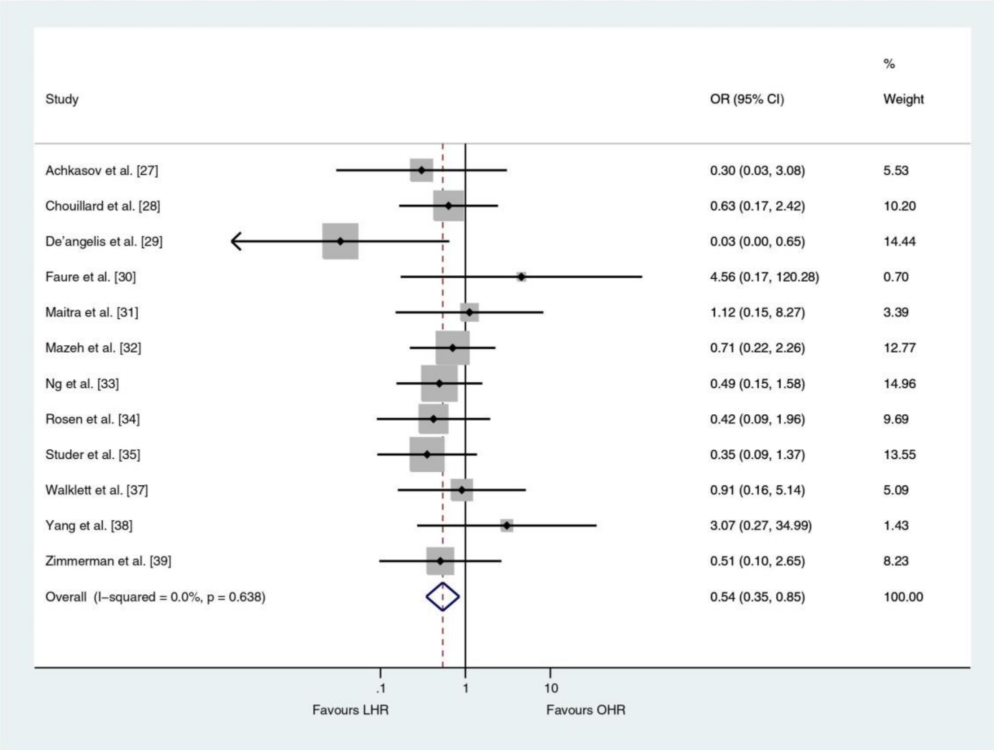


Fig. 3 Forest plot comparing wound infection after laparoscopic Hartmann's reversal (*LHR*) vs open Hartmann's reversal (*OHR*). A fixed-effects model was used for meta-analysis. An odds ratio (*OR*) less than 1 indicates a lower incidence of wound infection in LHR group

in both groups, a 0.5 correction was added in both cells to incorporate all available data in the meta-analysis and to maintain analytic consistency [20].

To explore the influence of potential effect modifiers on outcomes, a random-effects meta-regression analysis [21] was performed: relevant study characteristics (year of publication and study period), the number of not balanced baseline characteristics, the comparability of both groups for each variable, the NOS score, the mean time to reversal for each group, and the mean difference in reversal time for each group were tested as potential effect modifiers.

Publication bias was assessed using plots of study results against precision of the study (funnel plots) for each outcome. Symmetry of the funnel plots was tested using Peters' test [22] and Harbord's modified test [23].

Statistical analysis was performed using STATA 12 statistical software (STATA Corp, College Station, Texas, USA).

Results

Study selection

The search of Medline, Scopus, Web of Science, Embase, and the Cochrane Central Register of controlled trials provided 2677 citations, while three additional articles were retrieved by checking the references [24–26]. Seven hundred eighteen duplicates were removed, and after exclusion of 1862 not relevant articles at title and abstract level, 100 full-text articles were assessed for eligibility; finally 13 studies [27–39] were included in the meta-analysis. A flowchart is shown in Fig. 1. No unpublished relevant studies were found.

Study characteristics and quality assessment

The selected studies included 862 patients: 403 LHR (46.75 %) and 459 OHR (53.25 %). Conversion to open surgery occurred in 65 patients (mean 16.1 %, range 0–50 %) and

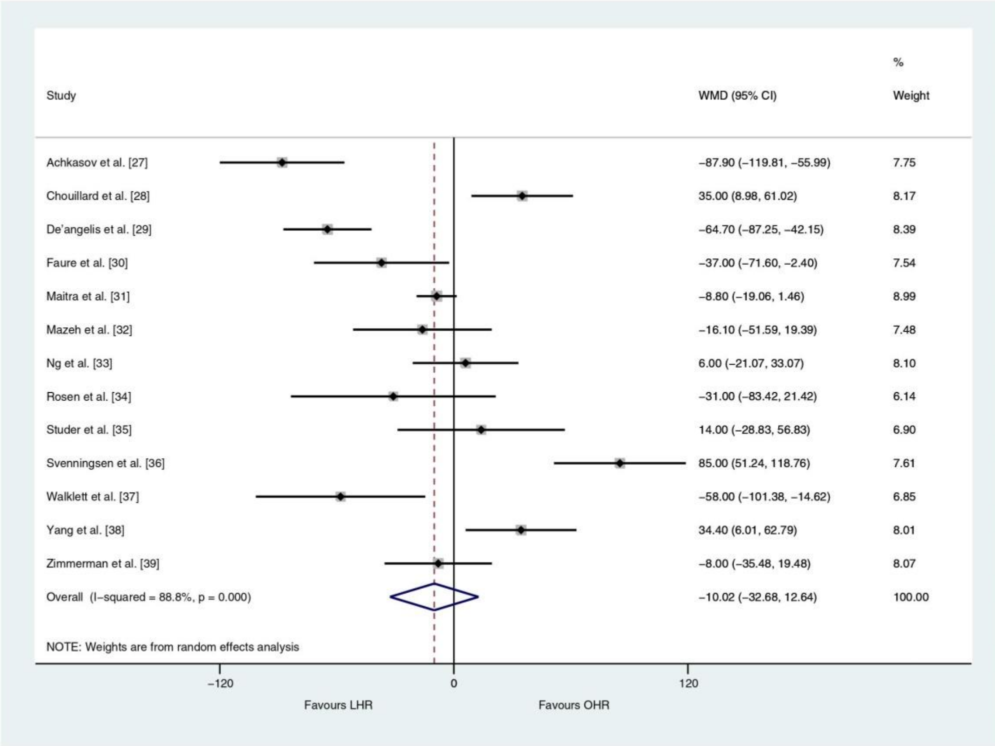


Fig. 4 Forest plot comparing operating time for laparoscopic Hartmann's reversal (*LHR*) vs open Hartmann's reversal (*OHR*). A random-effects model was used for meta-analysis. A negative weighted mean difference (*WMD*) indicates a shorter operating time in the LHR group

was reported in all the studies. Characteristics of the included studies and baseline patient populations are shown in Table 2. Results of the quality assessment by the Newcastle-Ottawa scale and comparability of populations for baseline variables are shown in Table 3.

LHR and OHR populations

No difference was found between LHR and OHR populations regarding age (WMD, −0.57; 95 % CI, −2.67 to 1.53), sex (OR, 1.15; 95 % CI, 0.87 to 1.51), BMI (WMD, −0.41; 95 % CI, −1.76 to 0.93), and ASA score ≥3 (OR, 0.85; 95 % CI, 0.51 to 1.39). The indication for the HP (benign vs malignant) did not significantly differ across the two groups (OR, 1.37; 95 % CI, 0.95 to 1.99), while the lag time (months) between the HP and its reversal was significantly shorter in the LHR group (WMD, −1.45; 95 % CI, −2.45 to −0.45).

Outcome analysis

The outcomes reported in the included studies are summarized in Tables 4 and 5.

All studies provided information on *30-day mortality*, showing no differences between LHR and OHR (OR, 1.13; 95 % CI, 0.41 to 3.15) with no heterogeneity across the included studies (Q=1.5; p=1).

LHR was associated with a reduced *overall postoperative 30-day morbidity* compared to OHR (Fig. 2) as reported in all the included studies (OR, 0.24; 95 % CI, 0.17 to 0.34) with no heterogeneity (Q=12.44, p=0.40).

Wound infection (OR, 0.54; 95 % CI, 0.35 to 0.85; Q=8.82, p=0.64, Fig. 3) and *postoperative ileus* (OR, 0.47; 95 % CI, 0.25 to 0.87; Q=6.72, p=0.45) were more commonly observed in the open group as reported in 12 studies [27–35, 37–39]; no difference was found in the *anastomotic leak* rate between the two groups

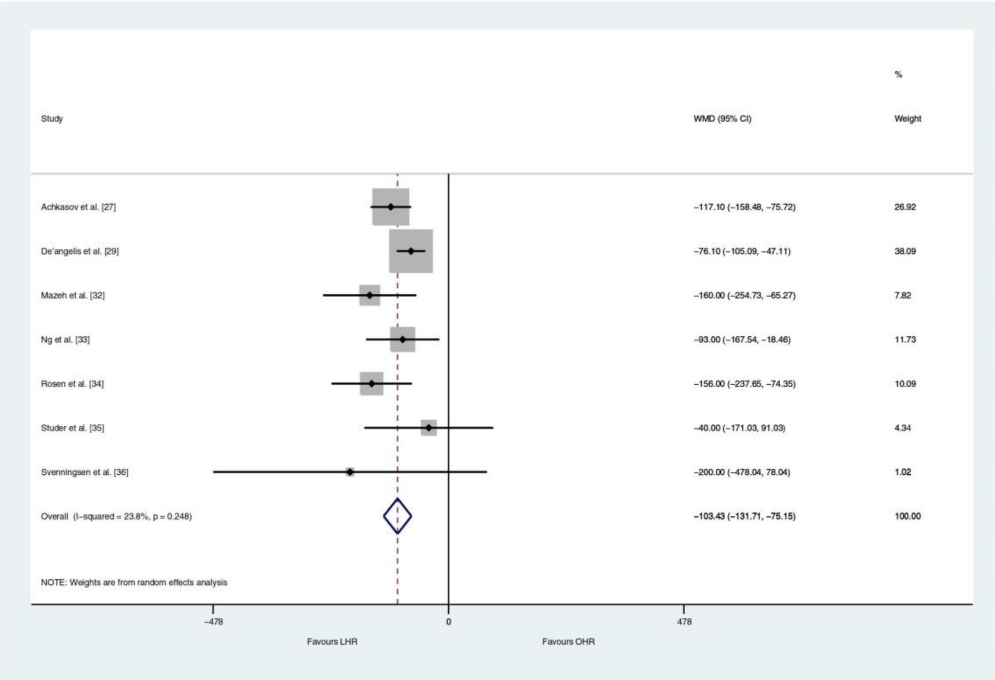


Fig. 5 Forest plot comparing estimated blood loss during laparoscopic Hartmann's reversal (*LHR*) vs open Hartmann's reversal (*OHR*). A random-effects model was used for meta-analysis. A negative weighted mean difference (*WMD*) indicates a reduced blood loss in the LHR group

(OR, 0.42; 95 % CI, 0.14 to 1.27; Q=3.54, p=0.83) [27–35, 37–39].

As reported in all the studies, there was no difference in the *operating time* (WMD, −10.02; 95 % CI, −32.68 to 12.64; significant heterogeneity Q=107.18, p=0.00) between the groups (Fig. 4), but a reduced *EBL* (Fig. 5) was found in the LHR group (WMD −103.432, 95 % CI −131.712 to −75.152, Q 7.87 p= 0.248) [27, 29, 32–36].

LOS was reported in all studies (Fig. 6) and was found to be shorter in the laparoscopic group (WMD, −3.34; 95 % CI, −4.97 to −1.71) as it was the time to flatus (WMD, −0.99; 95 % CI, −1.41 to −0.58), reported in nine studies [27–30, 32, 34, 36, 38, 39]. A significant heterogeneity was present in the last two analyses, respectively, I^2=90.4 % (Q=125.1, p=0.00) and I^2=70.2 % (Q=26.87, p=0.001).

Thirty-day reoperations were reported in 10 studies [28–34, 36, 38, 39] with no significant difference between the two groups (OR, 0.48; 95 % CI, 0.20 to 1.15; Q=5.34, p=0.8) (Fig. 7), while 30-day readmissions were only reported in two studies [31, 34].

Sensitivity analysis and publication bias

Study-exclusion analysis confirmed the results in all cases with the only exception of postoperative ileus: the lesser incidence in the LHR group was no more confirmed after the omission of the studies by Ng et al. (OR, 0.57; 95 % CI, 0.29 to 1.10) [33] and by Rosen et al. (OR, 0.53; 95 % CI, 0.28 to 1.01) [34].

Meta-regression analysis showed that the results were independent from potential modifiers, like study characteristics as year of publication, year in which the study started, multicenter trial, design (consecutive series vs case-matched), and conversion rate. Results were also independent from the quality of the study (estimated by the NOS score) and from the balance of the baseline variables; the presence of a disparity between the mean age of the groups was the only factor that influenced the results in terms of LOS: in fact, when the age was balanced, the advantages for the laparoscopic group were less pronounced, even if still statistically significant (OR, −2.53; 95 % CI, −3.68 to −1.38).

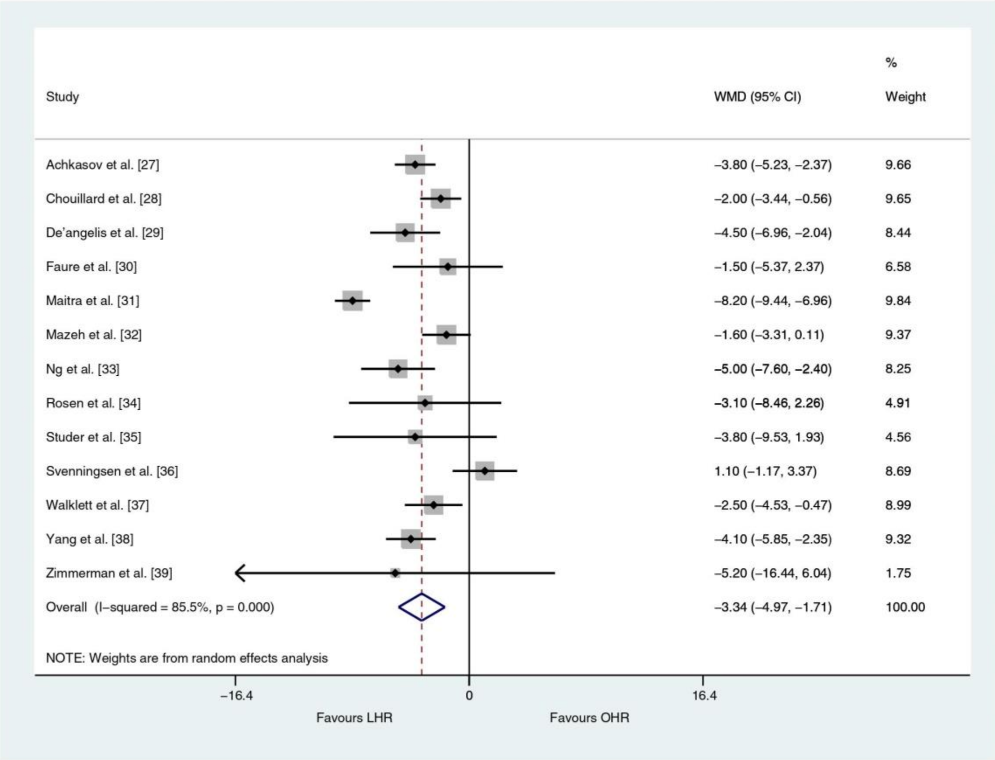


Fig. 6 Forest plot comparing length of hospital stay after laparoscopic Hartmann's reversal (*LHR*) vs open Hartmann's reversal (*OHR*). A random-effects model was used for meta-analysis. A negative weighted mean difference (*WMD*) indicates a shorter stay in LHR group

Funnel plot for the primary outcome showed symmetry (Fig. 8); this was confirmed by Peters' (p=0.71) and Harbord's modified (p=0.14) tests.

Discussion

Main finding of the study is that LHR is associated with reduced short-term morbidity compared to OHR: wound infections, as expected [40], were significantly less commonly observed in the laparoscopic group, as it was postoperative ileus, with no significant heterogeneity across the studies included in the meta-analysis. The laparoscopic approach to the HR confirms the benefits of minimally invasive surgery previously demonstrated for other colorectal procedures [41, 42] in terms of patient earlier recovery; indeed, we found a significant reduction in LOS together with a quicker resume of bowel functions.

LHR is one of the most technically demanding procedures in minimally invasive colorectal surgery [43] with further less than 20 % of the reversal procedures being attempted laparoscopically [44]; furthermore, the procedure is also affected by a high conversion rate, ranging from 0 to 50 % in our review (mean 16.1 %, 65 out of 403 patients) even worse than previously reported [7], with most commonly reasons for conversion including adhesions and failed identification or injury of the rectal stump.

A reduced conversion rate has been advocated when the index HP is performed laparoscopically [28], but our systematic review demonstrated lack of available data, with only two of the included studies [28, 29] and one of the excluded [45] correlating the feasibility of the LHR to the type of approach chosen at the time of the Hartmann's resection.

No significant difference in operating time was found between LHR and OHR, in contrast with previous series which reported a shorter operating time in the laparoscopic group [27, 29, 34, 46, 47]. The heterogeneity in the operating time

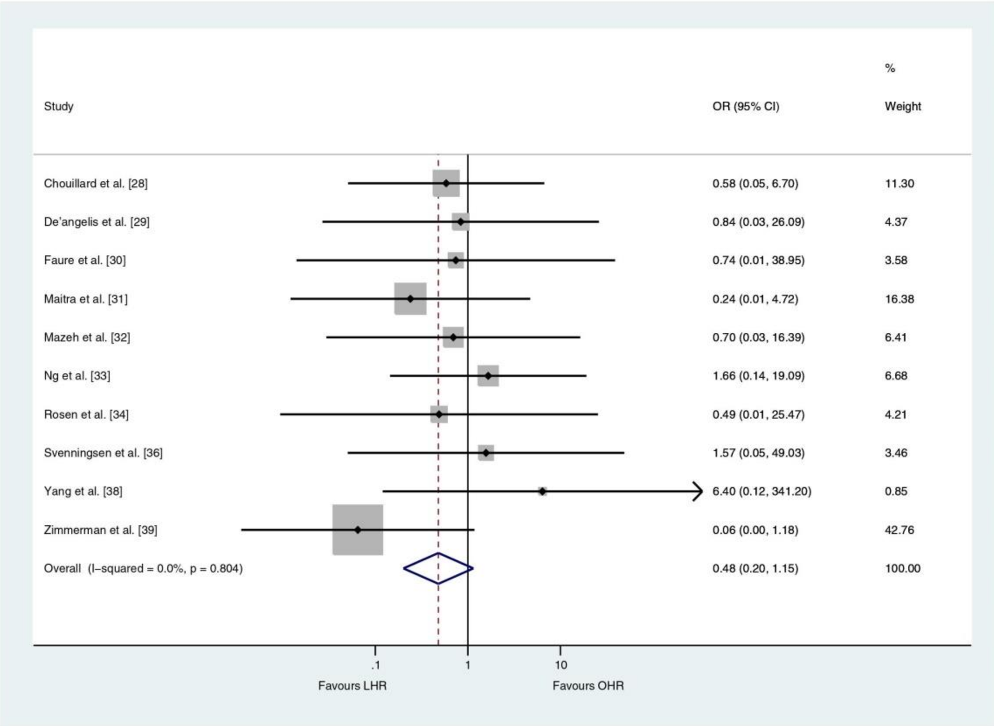
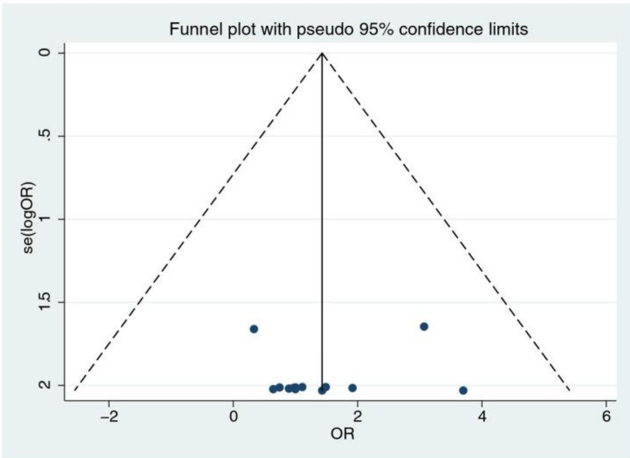


Fig. 7 Forest plot comparing reoperations after laparoscopic Hartmann's reversal (*LHR*) vs open Hartmann's reversal (*OHR*). A fixed-effects model was used for meta-analysis. An odds ratio (*OR*) less than 1 indicates a lower incidence of reoperations in LHR group

Fig. 8 Funnel plot of all studies included in the meta-analysis. The standard error (SE) of the ln odds ratio (OR) was plotted against the OR for 30-day mortality



across the studies could be addressed to a difference in laparoscopic technical skills among surgeons at different times of the learning curve; as a matter of fact, the reversal is only performed by a minimally invasive approach in a reduced number of cases and not every surgical center has a significant case load [37, 48].

It is important to note that we only included in the review studies conducted with an intention-to-treat analysis, including in the LHR group all the procedures attempted by a minimally invasive approach, even when converted to open surgery: our aim was to assess the overall benefits of the laparoscopic approach, and in view of this high conversion rate, an intention-to-treat was considered to be mandatory.

Our meta-analysis summarizes the most updated evidence on short-term outcomes of laparoscopic versus open approach for the reversal of Hartmann's procedure. A previous meta-analysis on this topic was conducted by Siddiqui et al. [47], but these authors had to face up with the lack of good comparative studies at that time (August 2008), thus including very small series leading to a significant heterogeneity.

Our meta-analysis has some limitations. As no randomized trials comparing LHR to OHR have been published so far, observational studies represent the best evidence on this topic; unfortunately, this type of evidences carry a high risk of selection bias. We addressed this selection bias by analyzing the demographic characteristics (age, sex, BMI, ASA score, nature of disease leading to the Hartmann's procedure) in LHR and OHR populations and demonstrating no significant differences between the two groups. Moreover, meta-regression analysis showed that our results were not significantly influenced by study period and design and presence of not balanced characteristics across the groups.

It is important to point out that some confounding factors may have led to select a patient for a minimally invasive approach rather than a conventional open procedure at the time of the reversal. We reported that in the LHR group, the reversal was performed after a shorter period from the resection time. Additionally, other factors related to the index HP like the surgical approach (laparoscopic vs open), the elective or emergency setting, and the Hinchey grade in case of diverticulitis may have influenced the surgical choice for the reversal; nevertheless, the impact of these potential, selection-determining factors on postoperative outcomes has to be demonstrated.

Our meta-analysis demonstrates that a laparoscopic approach to the reversal of Hartmann's procedure gives significant benefits to the patients in terms of reduced morbidity and shorter LOS; moreover, these advantages are confirmed in selected patients even when the not infrequent event of conversion to open surgery occurs. Our findings may lead to an increasing number of reversals being attempted laparoscopically; however, randomized controlled trials, with patients also stratified according to some characteristics of the primary resection (Hinchey grade, type of surgical approach), are mandatory before advising laparoscopic surgery as the gold standard technique for Hartmann's reversal.

Conclusions

LHR has less short-term complications than OHR in terms of overall morbidity, wound infection, and postoperative ileus. Moreover, LOS is shorter in the LHR group, while no significant difference exists in the operating time. Randomized clinical trials are advised to confirm these findings.

Conflict of interest The authors declare that they do not have competing interests.

Funding No fundings have been received for this work.

References

1. Hartmann H (1921) New procedure for the removal of cancers of the terminal part of the pelvic colon. Secretariat of the Association, Paris, pp 411–413
2. Gooszen AW, Tollenaar RA, Geelkerken RH et al (2001) Prospective study of primary anastomosis following sigmoid resection for suspected acute complicated diverticular disease. Br J Surg 88(5):693–697
3. Farthmann EH, Ruckauer KD, Haring RU (2000) Evidence-based surgery: diverticulitis—a surgical disease? Langenbecks Arch Surg 385(2):143–151
4. Desai DC, Brennan EJJ, Reilly JF et al (1998) The utility of the Hartmann procedure. Am J Surg 175(2):152–154
5. Vermeulen J, Gosselink MP, Busschbach JJ et al (2010) Avoiding or reversing Hartmann's procedure provides improved quality of life after perforated diverticulitis. J Gastrointest Surg 14:651–657
6. Banerjee S, Leather AJ, Rennie JA et al (2005) Feasibility and morbidity of reversal of Hartmann's. Color Dis 7:454–459
7. van de Wall BJ, Draaisma WA, Schouten ES et al (2010) Conventional and laparoscopic reversal of the Hartmann procedure: a review of literature. J Gastrointest Surg 14(4):743–752
8. Antolovic D, Reissfelder C, Ozkan T et al (2011) Restoration of intestinal continuity after Hartmann's procedure—not a benign operation. Are there predictors for morbidity? Langenbecks Arch Surg 396(7):989–996
9. Maggard MA, Zingmond D, O'Connell JB et al (2004) What proportion of patients with an ostomy (for diverticulitis) get reversed? Am Surg 70:928–931
10. Wigmore SJ, Duthie GS, Young IE et al (1995) Restoration of intestinal continuity following Hartmann's procedure: the Lothian experience 1987–1992. Br J Surg 82:27–30
11. Pearce NW, Scott SD, Karran SJ (1992) Timing and method of reversal of Hartmann's procedure. Br J Surg 79:839–841
12. Braga M, Vignali A, Zuliani W et al (2005) Laparoscopic versus open colorectal surgery: cost-benefit analysis in a single-center randomized trial. Ann Surg 242(6):890–895, **discussion 895-6**

13. Franklin ME Jr, Rosenthal D, Abrego-Medina D et al (1996) Prospective comparison of open vs. laparoscopic colon surgery for carcinoma. Five-year results. Dis Colon Rectum 39(10 Suppl): S35–S46
14. Gorey TF, O'Connell PR, Waldron D et al (1993) Laparoscopically assisted reversal of Hartmann's procedure. Br J Surg 80:109
15. Stroup DF, Berlin JA, Morton SC et al (2000) Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. JAMA 283(15):2008–2012
16. Deeks JJ, Dinnes J, D'Amico R et al (2003) Evaluating non-randomised intervention studies. International Stroke Trial Collaborative Group; European Carotid Surgery Trial Collaborative Group. Health Technol Assess 7(27):iii–x, **1-173**
17. Higgins JPT, Thompson SG, Deeks JJ et al (2003) Measuring inconsistency in meta-analyses. BMJ 327:557–560
18. Hozo SP, Djulbegovic B, Hozo I (2005) Estimating the mean and variance from the median, range, and the size of a sample. BMC Med Res Methodol 5:13
19. Furukawa TA, Barbui C, Cipriani A et al (2006) Imputing missing standard deviations in meta-analyses can provide accurate results. J Clin Epidemiol 59(1):7–10
20. Friedrich JO, Adhikari NK, Beyene J (2007) Inclusion of zero total event trials in meta-analyses maintains analytic consistency and incorporates all available data. BMC Med Res Methodol 7:5
21. Thompson SG, Sharp SJ (1999) Explaining heterogeneity in meta-analysis: a comparison of methods. Stat Med 18(20):2693–2708
22. Peters JL, Sutton AJ, Jones DR et al (2006) Comparison of two methods to detect publication bias in meta-analysis. JAMA 295(6): 676–680
23. Harbord RM, Egger M, Sterne JA (2006) A modified test for small-study effects in meta-analyses of controlled trials with binary endpoints. Stat Med 25(20):3443–3457
24. Schmelzer T, Mostafa G, Norton J et al (2007) Reversal of Hartmann's procedure: a high risk operation? Surgery 142:598–606
25. Carcoforo P, Navarra G, Di Marco L et al (1997) Reversal of Hartmann's procedure. Our experience. Ann Ital Chir 68:523–527
26. Regadas FS, Siebra JA, Rodrigues LV et al (1996) Laparoscopically assisted colorectal anastomose post-Hartmann's procedure. Surg Laparosc Endosc 6(1):1–4
27. Achkasov S, Vorobiev G, Zhuchenko A et al (2010) Laparoscopic-assisted reversal of Hartmann's procedure. Acta Chir Iugosl 57(3): 59–65
28. Chouillard E, Pierard T, Campbell R et al (2009) Laparoscopically assisted Hartman's reversal is an efficacious and efficient procedure: a case control study. Minerva Chir 64(1):1–8
29. De'angelis N, Brunetti F, Memeo R et al (2013) Comparison between open and laparoscopic reversal of Hartmann's procedure for diverticulitis. World J Gastrointest Surg 5(8):245–251
30. Faure JP, Doucet C, Essique D et al (2007) Comparison of conventional and laparoscopic Hartmann's procedure reversal. Surg Laparosc Endosc Percutan Tech 17(6):495–499
31. Maitra RK, Pinkney TD, Mohiuddin MK et al (2013) Should laparoscopic reversal of Hartmann's procedure be the first line approach in all patients? Int J Surg 11(9):971–976
32. Mazeh H, Greenstein AJ, Swedish K et al (2009) Laparoscopic and open reversal of Hartmann's procedure—a comparative retrospective analysis. Surg Endosc 23(3):496–502
33. Ng DC, Guarino S, Yau SL et al (2013) Laparoscopic reversal of Hartmann's procedure: safety and feasibility. Gastroenterol Rep (Oxf) 1(2):149–152
34. Rosen MJ, Cobb WS, Kercher KW et al (2006) Laparoscopic versus open colostomy reversal: a comparative analysis. J Gastrointest Surg 10(6):895–900
35. Studer P, Schnüriger B, Umer M et al (2014) Laparoscopic versus open end colostomy closure: a single-center experience. Am Surg 80(4):361–365
36. Svenningsen PO, Bulut O, Jess P et al (2010) Laparoscopic reversal of Hartmann's procedure. Dan Med Bull 57(6):A4149
37. Walklett CL, Yeomans NP (2014) A retrospective case note review of laparoscopic versus open reversal of Hartmann's procedure. Ann R Coll Surg Engl 96(7):539–542
38. Yang PF, Morgan MJ (2014) Laparoscopic versus open reversal of Hartmann's procedure: a retrospective review. ANZ J Surg 84(12): 965–969
39. Zimmermann M, Hoffmann M, Laubert T et al (2014) Laparoscopic versus open reversal of a Hartmann procedure: a single-center study. World J Surg 38(8):2145–2152
40. Poon JT, Law WL, Wong IW et al (2009) Impact of laparoscopic colorectal resection on surgical site infection. Ann Surg 249(1):77–81
41. Guillou PJ, Quirke P, Thorpe H 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(9472):1718–1726
42. Weeks JC, Nelson H, Gelber S et al (2002) Short-term quality-of-life outcomes following laparoscopic-assisted colectomy vs open colectomy for colon cancer: a randomized trial. JAMA 287(3):321–328
43. Jamali R, Soweid A, Dimassi H et al (2008) Evaluating the degree of difficulty of laparoscopic colorectal surgery. Arch Surg 143(8): 762–767
44. Arkenbosch J, Miyagaki H, Shantha Kumara HM et al (2014) Efficacy of laparoscopic-assisted approach for reversal of Hartmann's procedure: results from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. Surg Endosc. doi:10.1007/s00464-014-3926-7
45. Albrecht R, Bochmann C (2011) Sind eine laparoskopische Diskontinuitätsresektion und eine spätere laparoskopische Rekonstruktion bei der komplizierten Sigmadivertikulitis möglich? Zentralbl Chir 136(1):61–65
46. Haughn C, Ju B, Uchal M et al (2008) Complication rates after Hartmann's reversal: open vs. laparoscopic approach. Dis Colon Rectum 51(8):1232–1236
47. Siddiqui M, Sajid M, Baig M (2010) Open versus laparoscopic approach for reversal of Hartmann's procedure: a systematic review. Color Dis 12(8):733–741
48. Roig JV, Cantos M, Balciscueta Z et al (2011) Hartmann's operation: how often is it reversed and at what cost? A multicentre study. Color Dis 13(12):e396–e402

Publication n. 2

Giglio, M.C., Celentano, V., Tarquini, R., Luglio, G., De Palma, G.D., Bucci, L. (2015). Conversion during laparoscopic colorectal resections: a complication or a drawback? A systematic review and meta-analysis of short-term outcomes. *Int J Colorectal Dis*. (2015) Nov; 30(11): 1445-55.

Int J Colorectal Dis
DOI 10.1007/s00384-015-2324-5

REVIEW

Conversion during laparoscopic colorectal resections: a complication or a drawback? A systematic review and meta-analysis of short-term outcomes

Mariano Cesare Giglio[1] · Valerio Celentano[1] · Rachele Tarquini[1] · Gaetano Luglio[1] · Giovanni Domenico De Palma[1] · Luigi Bucci[1]

Accepted: 9 July 2015

Abstract
Purpose Several studies compared the outcomes of laparoscopically completed colorectal resections (LCR) to those requiring conversion to open surgery (COS). However, a comparative analysis between COS patients and patients undergoing planned open surgery (POS) would be useful to clarify if the conversion can be considered a simple drawback or a complication, being cause of additional postoperative morbidity. The aim of this study is to perform a meta-analysis of current evidences comparing postoperative outcomes of COS patients to POS patients.
Methods A systematic search of Medline, ISI Web of Knowledge, and Scopus was performed to identify studies reporting short-term outcomes of COS and POS patients. Primary outcomes were 30-day overall morbidity and length of postoperative hospital stay. Data were analyzed with fixed-effect modeling, and sensitivity analyses were performed to test the robustness of the results.
Results Twenty studies involving 30,656 patients undergoing POS and 1935 COS patients were selected. The mean conversion rate was 0.17. Similar 30-day overall morbidity and length of postoperative hospital stay were found in COS and POS patients. Wound infection (OR 1.43, 95 % CI 1.12 to 1.83, $p<0.01$) was higher in the COS group. Other results were robust. Outcomes were comparable for patients undergoing resection for different natures of the disease (benign vs. malignant) and at different sites (colon vs. rectum).
Conclusion Conversions from laparoscopic to open procedure during colorectal resection are not associated with a poorer postoperative outcome compared to patients undergoing planned open surgery, except for a higher risk of wound infection.

Keywords Laparoscopic colorectal resection · Conversion to open surgery · Short-term outcomes · Meta-analysis

Electronic supplementary material The online version of this article (doi:10.1007/s00384-015-2324-5) contains supplementary material, which is available to authorized users.

✉ Mariano Cesare Giglio
mariano.giglio@hotmail.it

[1] Dipartimento di Medicina Clinica e Chirurgia, Università degli Studi di Napoli Federico II, Via Sergio Pansini 5, 80131 Naples, Italy

Introduction

Conversion from laparoscopic to open procedure in colorectal surgery is reported with a widely variable rate (5.2 to 77 %) [1, 2]. Intention-to-treat analyses of randomized controlled trials (RCTs) considering procedures converted to open surgery (COS) for the laparoscopic group have shown that the minimally invasive approach is not inferior to the open approach [3–6]. Nevertheless, it is interesting to analyze the postoperative results in COS patients.

Several studies have compared the outcomes of COS procedures to laparoscopically completed colorectal resections (LCR), in some cases showing increased morbidity [7, 8], mortality [8], and length of hospital stay [9, 10]. However, the right yardstick for patients who require conversion during LCR should be patients undergoing planned open surgery (POS). A comparative analysis would clarify if the conversion has to be considered a simple drawback or a complication, causing additional postoperative morbidity. Evidence comparing these two groups of patients is controversial; some studies showed that COS patients may have a worse outcome in terms of postoperative course [3, 11, 12] and a poorer long-term oncologic outcome [13–15] than POS patients, while other

Published online: 21 July 2015

studies showed no differences [16, 17] and one study found better outcome [18].

The aim of this study is to perform a meta-analysis of current evidence, evaluating the short-term outcomes of COS procedures compared to POS ones.

Material and methods

Search strategy and selection criteria

We searched Medline, SCOPUS, and Web of Science with no language, publication date, or publication status restrictions. The last search was run on September 9, 2014, using the following search terms: "laparoscop*," "pneumoperitoneum," "conver*," "colon*," "colectomy," "colorectal," "rectum," "rectal," "sigmoid," "hemicolectomy," "crohn," and "ulcerative colitis" (Appendix 1, see Supporting information). The reference list of the identified articles was also checked to identify other potentially relevant studies.

To be considered eligible, a study had to report data on perioperative outcomes in patients undergoing planned open surgery (POS group) and in patients converted to open surgery (COS group) after a failed laparoscopic attempt. Studies including patients undergoing emergency colorectal resections were excluded. Two reviewers (MDs) independently assessed the reports for eligibility at the title and abstract levels. Divergences were resolved by a third reviewer. The full text of selected reports was then retrieved for further analysis.

Data extraction and methodological quality appraisal

Two authors independently extracted data from included studies and filled an electronic database with the following information: first author and publication year, study design, surgeon experience, definition of the term conversion, rate and

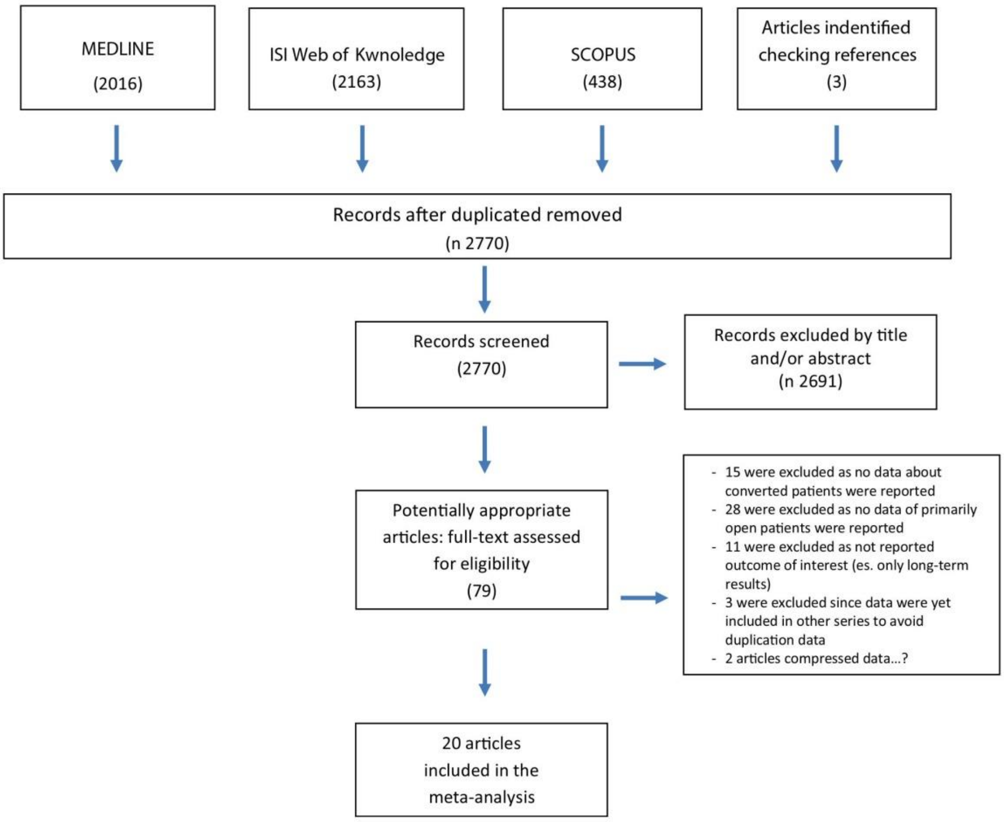


Fig. 1 Search strategy

reason of conversion, and characteristics of study population (age, gender, BMI, ASA index, nature of disease, type of resection, stage of disease).

The Newcastle–Ottawa scale (NOS) was used to assess the quality of a study on a scale of 9, with a greater score indicating better quality. Further assessment of the selection bias was made by considering if the COS and POS groups were comparable for six variables: age, gender, American Society Anesthesiology (ASA) index, body mass index (BMI), site of resection, and stage of disease. Thus, every study was considered to be at low (5–6), medium (3–4), or high risk (0–2) of selection bias, depending on the number of variables that were balanced. If a variable was missing, it was considered not to be balanced.

Outcome analysis

Primary outcomes were 30-day overall morbidity and length of postoperative hospital stay. Secondary outcomes were 30-day mortality, operating time, estimated blood loss, anastomotic leak, re-operation, postoperative bleeding, postoperative bowel obstruction, wound infection, pneumonia, sepsis, cardiovascular complications, and deep venous thrombosis. The odds ratio (OR) and 95 % confidence interval (95 % CI) were used as summary measures for discrete outcomes, while the weighted mean difference (WMD) and 95 % CI were used as summary measures for continuous outcomes. In the absence of statistical heterogeneity, the fixed-effect Mantel-Hænzel model was used. Otherwise, a random-effect DerSimonian and Laird model was used. The heterogeneity among the studies was tested by the Q statistic and quantified by the I^2 statistic. As a guide, I^2 values of <25 % indicated low heterogeneity, 25–50 % indicated moderate heterogeneity, and >50 % indicated high [19] heterogeneity. For dichotomous analyses with zero count cells, 0.5 was added to each cell. Subgroup analysis was planned to establish whether the type of disease (cancer) or type of resection (rectal, colonic) affected the results. The presence of a correlation between the year of the study and the conversion rate was assessed using Spearman's rho statistic.

Sensitivity analyses Additional analyses were performed to test if the results were robust to our methodological assumptions. When a fixed-effect model was used, the meta-analysis was repeated using a random-effect model. The influence of each individual study on the analysis was investigated by omitting each study in turn and re-estimating the summary effect and the heterogeneity.

To further explore whether the results were affected by potential confounding factors, a meta-regression analysis was performed. Study characteristics (year of publication, study design, surgeon experience, conversion rate), study

Table 1 Characteristics of included studies

Study	Multicenter	Type of resection	Disease	POS	LCR	COS	Conversion rate
Begos et al. [24]	No	Colon and rectum	ANY	34	50	17	0.34
Belizon et al. [11]	No	Colon	ANY	28	115	28	0.19
Bouvet et al.[25]	No	Colon and rectum	CANCER	57	53	38	0.42
Casillas et al. [16]	No	Colon	ANY	51	430	51	0.12
CLASICC trial [3]	Yes	Colon and rectum	CANCER	276	488	143	0.29
Curet et al. [22]	No	Colon	CANCER	18	25	7	0.28
Gonzalez et al. [18]	No	Colon and rectum	ANY	260	238	56	0.23
Hewett et al. [27]	Yes	Colon	CANCER	298	294	43	0.15
Kaiser et al. [26]	No	Colon	CANCER	20	29	13	0.46
Kang et al. [32]	Yes	Colon and rectum	ANY	5774	3171	602	0.16
Kolfschoten et al. [33]	Yes	Colon and rectum	CANCER	4287	3063	446	0.13
Laurent et al. [21]	No	Rectum	CANCER	233	238	36	0.15
Martinek et al. [28]	No	Colon and rectum	CANCER	226	243	17	0.07
Mroczkowski et al. [30]	Yes	Rectum	CANCER	16,308	1455	201	0.12
Pennincks et al. [31]	Yes	Rectum	CANCER	1896	764	88	0.12
Rickert et al. [34]	No	Rectum	CANCER	114	124	38	0.24
Rottoli et al. [29]	No	Colon and rectum	CANCER	155	62	31	0.10
Senagore et al. [23]	No	Colon and rectum	ANY	102	26	12	0.32
Slim et al. [12]	No	Colon and rectum	ANY	252	65	16	0.25
Strohlein et al. [15]	Yes	Rectum	CANCER	275	114	25	0.22

ANY resection both for benign and malignant disease, *POS* planned open surgery, *LCR* laparoscopic colorectal resections, *COS* converted to open surgery quality (NOS), and risk of selection bias were tested as potential effect modifiers. Publication bias was assessed by graphical inspection of the funnel plot to detect asymmetry. Symmetry of the funnel plot was also tested using Egger's linear regression method and Harbord's modified test. Statistical analyses were performed using STATA 12 statistical software (STATA Corp, College Station, Texas, USA). The study was realized according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement [20].

Results

Study selection

The search of the Medline, Web of Science, and Scopus databases provided a total of 4617 citations. Three additional studies [3, 21, 22] were identified by checking the references. One thousand eight hundred forty-seven duplicated studies were found and removed. Of the 2770 remaining, 2691 studies were discarded because they clearly did not meet the inclusion criteria after reviewing the title or abstract. The full text of the remaining 79 articles was examined in more detail. After excluding 59 studies, 20 studies [11, 12, 15, 16, 18, 23–36] were included in the meta-analysis (Fig. 1). No relevant unpublished studies were found.

Study characteristics and quality assessment

The selected studies included 41,741 patients: 30,656 patients underwent POS, while 11,085 patients had an LCR. Of these, 1935 were converted to an open procedure. The mean conversion rate was 0.17, ranging from 0.07 to 0.46. The more recent the study, the lower the conversion rate was (Spearman's rho −0.68, p=0.002). However, reasons for conversion to open surgery (intraoperative findings vs. complication) remained constant over the years (Spearman's rho −0.1, p=0.64). Characteristics of included studies are shown in Table 1. The indication for surgery was colorectal cancer in 13 studies [3, 15, 21, 22, 25–31, 33, 34], while seven studies [11, 12, 16, 18, 23, 24, 32] analyzed resections both for malignant and benign disease. Five studies included only rectal resections [15, 21, 30, 31, 34] while five studies analyzed colonic resections only [11, 16, 22, 26, 27]. Table 2 shows the assessment of the risk

Table 2 Assessment of risk of bias within the studies

Study	Primary allocation to POS or LCR	Study time	Matching of patients	Newcastle–Ottawa scale	Characteristics balanced between COS and POS patients						
					Age	Gender	ASA	Res. type	Disease	Tumoral stage	Bias risk
Begos et al. [24]	Nonrandom	RETROSPECTIVE	No	8	Yes	Yes	Yes	No	Yes	No	M
Belizon et al. [11]	Nonrandom	PROSPECTIVE	Yes	8	Yes	Yes	Yes	No	Yes	Yes	L
Bouvet et al. [25]	Nonrandom	PROSPECTIVE	No	7	Yes	Yes	No	Yes	Yes	Yes	L
Casillas et al. [16]	Nonrandom	PROSPECTIVE	Yes	8	Yes	Yes	Yes	No	Yes	No	M
CLASICC trial [3]	Random	PROSPECTIVE	No	8	Yes	Yes	Yes	No	Yes	Yes	L
Curet et al. [22]	Random	PROSPECTIVE	No	7	Yes	Yes	No	Yes	Yes	Yes	L
Gonzalez et al. [18]	Nonrandom	RETROSPECTIVE	No	8	Yes	Yes	Yes	No	Yes	Yes	L
Hewett et al. [27]	Random	PROSPECTIVE	No	6	No	No	No	No	No	No	H
Kaiser et al. [26]	Random	PROSPECTIVE	No	7	Yes	Yes	No	No	Yes	Yes	M
Kang et al. [32]	Nonrandom	RETROSPECTIVE	No	7	Yes	Yes	Yes	No	Yes	No	M
Kolfschoten et al. [33]	Nonrandom	RETROSPECTIVE	Yes	7	Yes	No	Yes	Yes	No	Yes	M
Laurent et al. [21]	Nonrandom	RETROSPECTIVE	No	6	No	No	No	No	No	No	H
Martinek et al. [28]	Nonrandom	PROSPECTIVE	No	7	Yes	Yes	No	Yes	Yes	Yes	L
Mroczkowski et al. [30]	Nonrandom	RETROSPECTIVE	No	5	No	No	No	No	No	No	H
Pennincks et al. [31]	Nonrandom	RETROSPECTIVE	Yes	8	Yes	Yes	Yes	Yes	Yes	Yes	L
Rickert et al. [34]	Nonrandom	PROSPECTIVE	No	8	Yes	Yes	Yes	Yes	Yes	Yes	L
Rottoli et al. [29]	Nonrandom	PROSPECTIVE	Yes	8	Yes	Yes	Yes	Yes	Yes	Yes	L
Senagore et al. [23]	Nonrandom	PROSPECTIVE	No	7	Yes	No	No	No	No	No	H
Slim et al. [12]	Nonrandom	RETROSPECTIVE	No	8	Yes	No	Yes	No	No	No	H
Strohlein et al. [15]	Nonrandom	PROSPECTIVE	No	7	Yes	No	No	Yes	No	Yes	M

POS planned open surgery, *COS* converted open surgery, *ASA* American society of anesthesiology index, *L* low (5–6 characteristics balanced), *M* medium (3–4 characteristics balanced), *H* high (0-2 characteristics balanced)

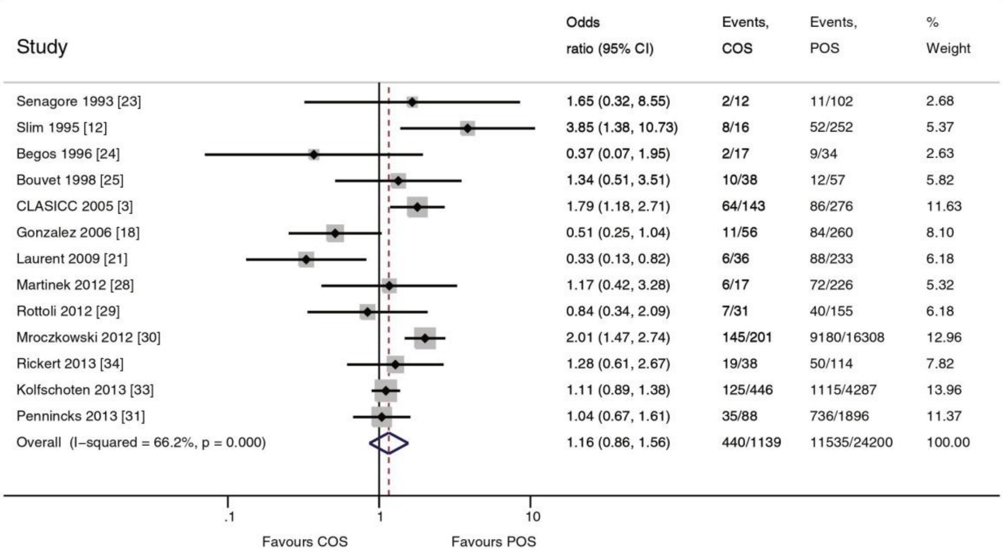


Fig. 2 Forest plot comparing 30-day overall morbidity for planned open surgery (POS) vs. laparoscopic resections converted to open surgery (COS). A random-effect model was used for the analysis. An odds ratio above 1 indicates a higher morbidity in the COS group

Table 3 Definition of conversion

Study	Definition of conversion
Begos et al. [24]	Incision larger than required for specimen retrieval
Belizon et al. [11]	Abortion of laparoscopic approach and the performance of a conventional abdominal incision OR incision>6 cm
Bouvet et al. [25]	Need to convert a laparoscopic colectomy in an open colectomy
Casillas et al. [16]	Incision <10 cm or operating through the incision if <10 cm
CLASICC trial [3]	Vertical incision greater than planned
Curet et al. [22]	Laparotomy
Gonzalez et al. [18]	Extending one of the incisions to perform any step of the procedure other than the anastomosis or specimen removal, or performing a formal laparotomy to complete the operation. In the case of hand-assisted laparoscopic surgery (HALS), extending incision of the hand port used originally to fit the surgeon's hand to perform any part of the operation was considered a conversion
Hewett et al. [27]	Making a larger skin incision than was originally planned at the commencement of the operation
Kaiser et al. [26]	n.d.
Kang et al. [32]	n.d.
Kolfschoten et al. [33]	Procedure started with the intention to resect the tumor using laparoscopic resection but completed as open resection
Laurent et al. [21]	Conventional midline laparotomy or incision greater than needed for specimen retrieval
Martinek et al. [28]	Unplanned laparotomy or wound enlargement above the necessity for specimen removal
Mroczkowski et al. [30]	Procedures started in laparoscopic manner and ended in open manner
Pennincks et al. [31]	n.d.
Rickert et al. [34]	Incision (laparotomy or Pfannenstiel) larger than minilaparotomy
Rottoli et al. [29]	Laparotomy created for any purpose other than specimen extraction
Senagore et al. [23]	n.d.
Slim et al. [12]	Abandonment laparoscopic procedure and midline laparotomy incision
Strohlein et al. [15]	n.d.

n.d. conversion not defined

of bias. The definition of the term "conversion" in the selected studies is reported in Table 3.

Outcome analysis

All studies provided information on *30-day mortality*, and the Forest plot showed no difference between COS and POS (OR, 1.1; 95 % CI, 0.83 to 1.46). The incidence of overall postoperative *30-day morbidity* was reported in 13 studies [3, 12, 18, 21, 23–25, 28–31, 33, 34]. The results were similar in the two groups (OR, 1.16; 95 % CI, 0.86 to 1.56) although a significant heterogeneity was found (Q, 35.5; p=0; I^2=66.2 %) (Fig. 2). Conversion to open surgery was associated with a higher incidence of postoperative *pneumonia* (OR, 1.54; 95 %

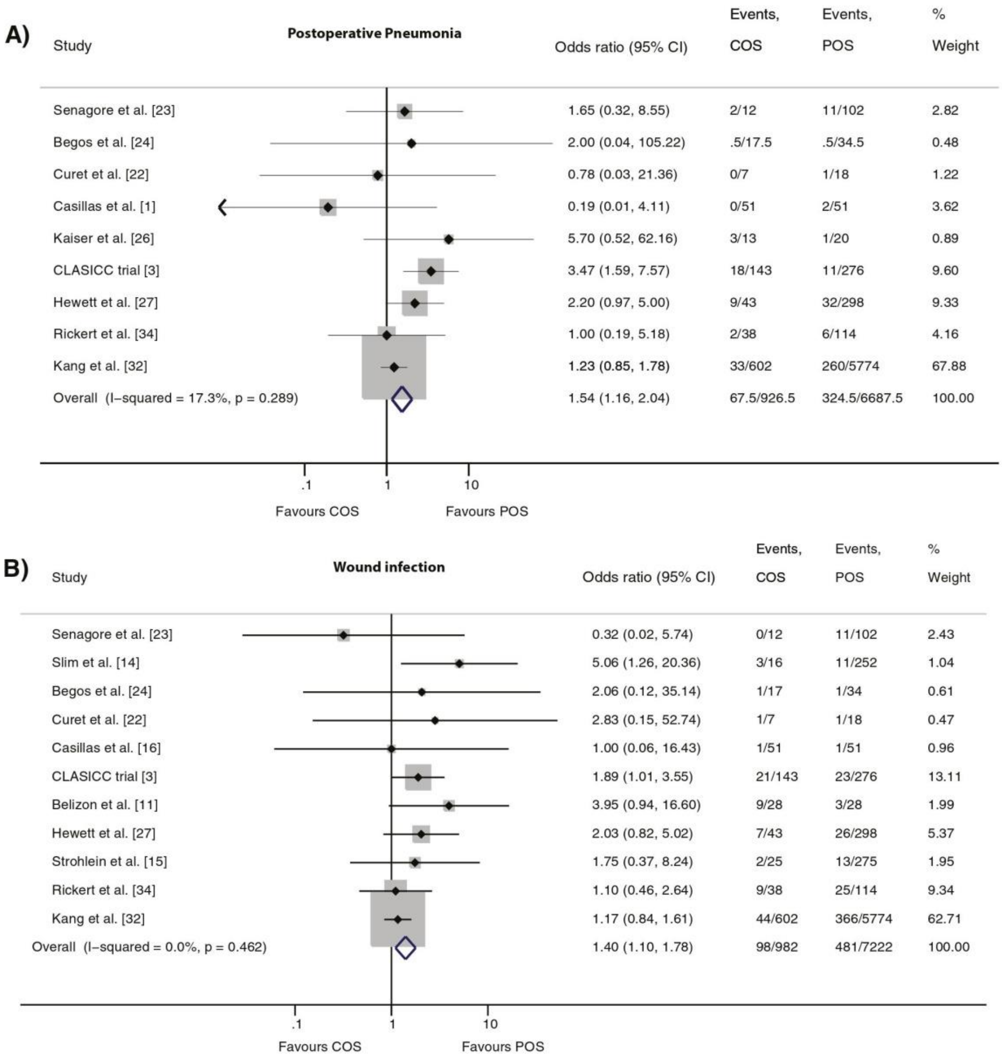


Fig. 3 Forest plot comparing incidence of postoperative pneumonia (**a**) and wound infection (**b**) after planned open surgery (POS) vs. laparoscopic resections converted to open surgery (COS). A fixed-effect model was used for the analyses. An odds ratio above 1 indicate a higher incidence in the COS group

CI, 1.16 to 2.04) as reported in nine studies [3, 16, 22–24, 26, 27, 32, 34] (Fig. 3a). Furthermore, the rate of *wound infection* was compared in 11 studies [3, 11, 12, 15, 16, 22–24, 27, 32, 34], and it was found to be higher in COS group (OR, 1.43; 95 % CI, 1.12 to 1.83) (Fig. 3b). The *length of hospital stay* was reported in 14 studies [3, 12, 15, 16, 18, 24–28, 31, 32, 34] (Fig. 4) with no difference between COS and POS (WMD, −0.12; 95 % CI, −1.14 to 0.89; significant heterogeneity Q, 65.10; p=0, I^2=96.9 %) as for *anastomotic leak* rate (OR, 1.08; 95 % CI, 0.88 to 1.33) that was recorded in seven studies [3, 11, 15, 24, 29, 32, 34]. *Operating time* [11, 12, 16, 18, 22, 24–26, 28, 34, 37] was longer in the COS group (WMD, 57.59; 95 % CI, 44.55 to 70.63), while no difference was found in *blood loss* (WMD, 36.34: 95 % CI, −122.79 to 195.48), reported in five studies [18, 22, 23, 26, 28]. Among other secondary outcomes investigated, no differences were found in rates of *re-operation*, *postoperative bleeding*, *postoperative obstruction*, *sepsis*, *cardiac complication*, and *deep venous thrombosis* (Table 4). Subgroup analysis confirmed the results when studies were considered according to the nature of disease and site of resection (Table 5).

Sensitivity analysis and publication bias

The results obtained using a fixed-effect model were confirmed by repeating the analysis using a random-effect model (Table 4). The influence analysis showed that after exclusion of the studies by Hewett et al. [27] (OR, 1.64; 95 % CI, 0.92 to 2.91) or Guillou at al. [3] (OR, 1.35; 95 % CI, 0.98 to 1.86), there was no more difference in the risk of pneumonia. Meta-regression analysis showed that the results were not influenced by the quality of the study, the selection bias, or other study characteristics (Table 6). The funnel plot showed symmetry (Fig. 5), which was confirmed by Egger's and Harbord's modified tests (p>0.6 for all tests).

Discussion

Several studies have compared the outcomes of COS procedures to laparoscopic completed colorectal resections. However, the right term for comparison of patients who required COS should be patients undergoing POS. Surgeons should answer the question, "*Would the patient's outcome have changed if the operation had been planned primarily as an open case?*" In addition, when informing the patient about the procedure, a failed laparoscopic attempt should be presented not simply as a drawback, but as a complication, if the conversion is associated with a poorer postoperative outcome than POS.

The main finding of the study is that the postoperative course of COS patients does not differ from that of POS patients, except for a higher risk of wound infection. No difference was found in 30-day overall morbidity between COS and POS patients. Previously, two studies found a higher

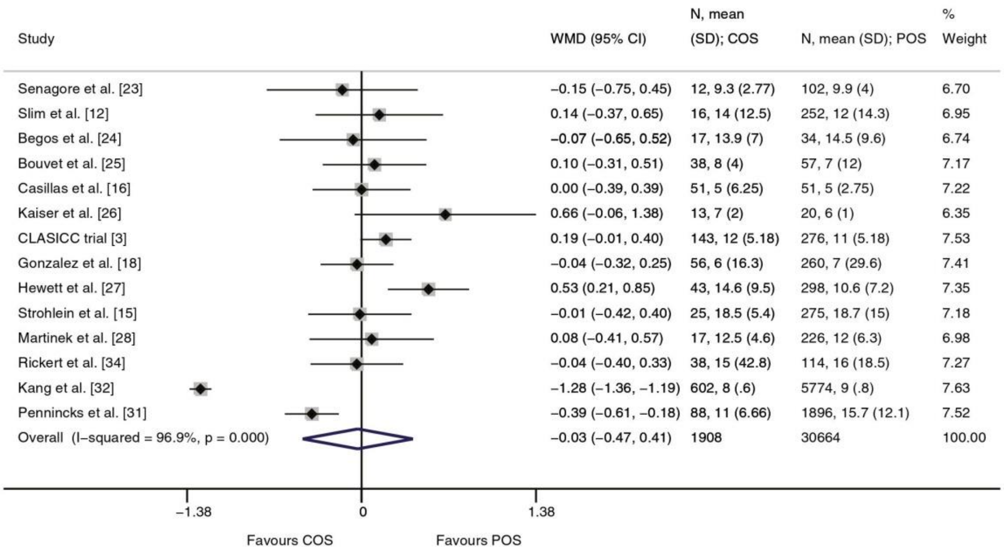


Fig. 4 Forest plot comparing length of hospital stay after planned open surgery (POS) vs. laparoscopic resections converted to open surgery (COS). A random-effect model was used for the analysis. A positive weighted mean difference (WMD) indicates longer hospital stay in the COS group

Table 4 Summary of outcomes of included studies: planned open surgery vs. converted open surgery

Outcome	Number of data sets	Summary effect	Model	Heterogeneity	Random-effect model analysis
30-day mortality	20	OR=1.102 [0.830–1.463] p=0.50	FE	Q=7.6 p=0.99	OR=1.144 [0.856–1.528] p=0.363
30-day morbidity	13	OR=1.159 [0.862–1.558] p=0.31	RE	Q=35.53 p=0.00 I^2=66.2 %	
Wound infection	11	OR=1.4 [1.1–1.783] p=0.006	FE	Q=9.75 p=0.462	OR=1.428 [1.116–1.828] p=0.005
Anastomotic leak	7	OR=1.081 [0.877–1.331] p=0.467	FE	Q=5.30 p=0.505	OR=1.095 [0.887–1.353] p=0.397
Pneumonia	9	OR=1.536 [1.156–2.041] p=0.003	FE	Q=9.66 p=0.209	OR=1.729 [1.090–2.73] p=0.02
Cardiac complications	4	OR=0.829 [0.508–1.352] p=0.453	FE	Q=0.90 p=0.827	OR=0.830 [0.505–1.363] p=0.453
Postoperative bleeding	4	OR=0.355 [0.076–1.669] p=0.190	FE	Q=0.02 p=0.999	OR=0.354 [0.076–1.637] p=0.184
Deep venous thrombosis	4	OR=0.622 [0.212–1.818] p=0.385	FE	Q=0.19 p=0.979	OR=0.638 [0.215–1.887] p=0.416
Sepsis	4	OR=1.091 [0.394–3.024] p=0.866	FE	Q=2.86 p=0.414	OR=1.534 [0.455–5.174] p=0.490
Operating time (min)	12	WMD=57.593 [44.550–70.637] p=0.00	RE	Q=83.45 p=0.00 I^2=86.8 %	
Re-operation	5	OR=0.909 [0.706–1.171] p=0.460	FE	Q=3.00 p=0.558	OR=0.910 [0.705–1.175] p=0.470
Postoperative obstruction	4	OR=2.466 [0.470–12.950] p=0.286	FE	Q=0.10 p=0.949	OR=2.458 [0.453–13.346] p=0.297
Length of hospital stay	14	WMD=−0.124 [−1.144–0.895] p=0.811	RE	Q=65.10 p=0.00 I^2=96.9 %	
Blood loss (ml)	5	WMD=36.34 [−122.79–195.48] p=0.654	RE	Q=58.85 p=0.00 I^2=92.3 %	

Weighted mean difference (WMD) for continuous variables and odds ratio (OR) for complications, all with 95 % confidence interval

Positive WMD and OR above 1 favor planned open surgery (POS)

FE fixed-effect model, *RE* random-effect model, *Q* Cochrane index

Table 5 Subgroup analysis on mortality, overall morbidity and length of hospital stay according to site of resection and indication for surgery

Outcome	Number of data sets	Summary effect	Model	Heterogeneity
SUBGROUP disease CANCER				
30-day mortality	13	OR=1.21 [0.871–1.697] p=0.25	FE	Q=4.07 p=0.982
30-day morbidity	9	OR=1.212 [0.905–1.622] p=0.197	RE	**Q=22.48 p=0.004 I^2=64.4 %**
Length of hospital stay	8	WMD=0.226 [−1.740–2.191] p=0.82	RE	**Q=51.87 p=0.01 I^2=86.5**
SUBGROUP type of resection COLON				
30-day mortality	5	OR=2.492 [0.564–10.998] p=0.22	FE	Q=0.58 p=0.96
30-day morbidity	-	–	–	–
Length of hospital stay	3	WMD=1.30 [−0.429–3.029] p=0.14	RE	Q=5.04 p=0.08
SUBGROUP type of resection RECTUM				
30-day mortality	5	OR=1.102 [0.830–1.463] p=0.79	FE	Q=0.75 p=0.945
30-day morbidity	13	1.065 0.567 2.000 p=0.36	RE	**Q=16.64 p=0.001 I^2=82.4 %**
Length of hospital stay	4	WMD=−2.519 [−6.454–1.417] p=0.21	RE	**Q=8.03 p=0.01 I^2=75.1 %**

Bold emphasis is to highlight that the statistical heterogeneity (Q test) was significant

FE fixed-effect model, *RE* random-effect model, *OR* odds ratio, *WMD* weighted mean difference, *Q* Cochrane index

Table 6 Effect of potential effect modifiers on main outcomes

	Outcome			
	Mortality	Morbidity	Hospital stay	Wound infection
Δduration (COS–POS)	0.005 p=0.31	0.001 p=0.75	0.0032009 p=0.34	0.001 p=0.83
Learning curve	0.642 p=0.52	0.221 p=0.77	−0.0915573 p=0.67	0.363 p=0.72
Disease (cancer/benign)	0.322 p=0.34	0.113 p=0.80	0.3974207 p=0.14	0.084 p=0.82
Type of resection (colon/rectum)	−0.159 p=0.59	0.079 p=0.83	−0.2289881 p=0.17	−0.183 p=0.41
Matching (yes/no)	−0.013 p=0.96	−0.164 p=0.68	−0.190211 p=0.62	0.673 p=0.35
Study time (prospective/retrospective)	0.484 p=0.17	0.250 p=0.50	0.5376222 p=0.12	0.224 p=0.51
Newcastle–Ottawa scale	0.057 p=0.76	−0.050 p=0.78	−0.0915573 p=0.67	0.149 p=0.58
Numbers of variables matched	0.030 p=0.76	0.034 p=0.68	0.0667436 p=0.39	0.059 p=0.57
Primary allocation (randomized/not randomized)	0.630 p=0.12		0.6104352 p=0.14	0.399 p=0.22
Conversion rate	0.960 p=0.74	0.062 p=0.97	1.370128 p=0.30	1.40 p=0.75
Year of the study	−0.049 p=0.16	−0.017 p=0.54	−0.0237594 p=0.24	−0.023 p=0.06

COS converted to open surgery, *POS* planned open surgery

morbidity in the COS group [3, 12], but Slim et al. [12] reported data from an early laparoscopic experience. Consistent with this result, there was no difference in the length of postoperative hospital stay. Moreover, our analysis did not show any difference in the risk of anastomotic complication after conversion, in contrast to findings by Belizon et al. [11] and Slim et al. [12]. As expected, the operating time was longer in the COS group, which could explain the higher risk of pneumonia in these patients [3] revealed in our analysis. However, this result was not robust, since it depended on the singular inclusion of two [3, 27]. In particular, the study by Hewett et al. [27] has high risk of selection bias. Thus, we think that no conclusion should be drawn about the risk of pneumonia in COS patients. Despite the conversion rate decreasing in more recent studies, the outcomes of COS patients were substantially comparable to those of POS patients over the years. Consistent with this result, surgeon experience and the reason for conversion (findings vs. intraoperative complications) did not worsen postoperative outcomes in COS patients. This could be because most of the intraoperative complications that occurred could be repaired without having a significant impact on the postoperative course.

Some methodological aspects and limitations of this study should be considered. An inherent risk of selection bias is present in this analysis. The COS group is a negatively selected group, as patients requiring conversion are usually older, have more comorbidities, or have an advanced stage of disease [38, 39]. Additionally, in a nonrandomized setting, patients could have been selected for POS in view of the same characteristics. Each of these aspects alone could cause a poorer postoperative outcome, independently from the procedure (POS or COS).

In addition to the study quality (NOS), we assessed the presence of a selection bias by considering if the groups (POS and COS) were comparable for six variables (age, gender, ASA index, BMI, site of resection, stage of disease), which are risk factors for conversion and could act as confounding factors [38, 39]. The meta-regression analysis showed that the results did not change according to the NOS score, the number of variables balanced, and the status of each of these variables (balanced vs. not balanced). Another potential confounding factor is the number of previous surgeries. Unfortunately, this factor could not be considered in this assessment, since it was not reported in most of the studies. However, this and other unknown confounding factors are more likely to have been a cause of higher morbidity in the COS group than in our analysis, which does not show a substantial difference of morbidity.

The design of the included studies was heterogeneous (Table 1). We should point out that in this comparison, RCTs lose their advantages. Although POS and LCR groups are fully comparable because of randomization, the COS group is not comparable to the POS group as a result of the negative selection (Table 2). In view of the unpredictability of the conversion event [40], an observational study remains as the only

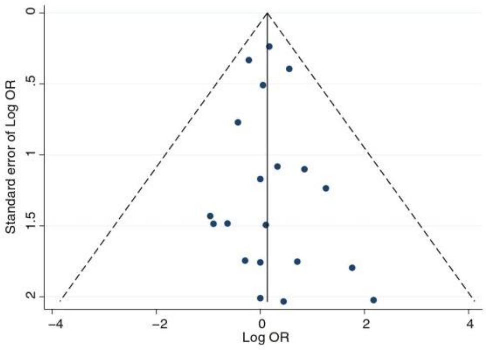


Fig. 5 Funnel plot. The standard error (SE) of the logarithm of the odds ratio (OR) is plotted against the logarithm of the OR (outcome 30-day mortality)

conceivable evidence to study this topic. Compared to retrospective studies, prospective ones have a lower risk of measurement bias. However, sensitivity analysis showed that the results were comparable for prospective and retrospective studies. Study populations were heterogeneous according to the nature of disease (benign vs. malignant), the site of the disease (colon vs. rectum), and consequently, the type of operation. Subgroup analyses revealed comparable outcomes for these categories of patients.

Inter-study heterogeneity was present in the analysis of overall morbidity. This is a composite outcome, and a varying definition of the composition could account for this heterogeneity. This hypothesis is supported by the fact that no statistical heterogeneity was present in the analysis of each single outcome of morbidity. The definition of conversion varied across the studies, as there is still no consensus on this term. Nevertheless, the varying definition of conversion did not correspond with significant heterogeneity of the outcomes. This suggests that in most of the studies, the definition differed mainly on a formal level.

Intention-to-treat analyses of RCTs have shown that a minimally invasive approach is not inferior to the open approach when COS procedures are considered in the laparoscopic group [3–6]. This evidence might support a surgeon's choice to attempt a minimally invasive colorectal resection when a laparoscopic operation is feasible and there are no obvious contraindications. We believe that our results further support this strategy, adding valuable information that the postoperative course of converted patients does not differ from that of patients undergoing POS, except for a higher risk of wound infection.

Conflict of interest The authors declare that they have no competing interests.

References

1. Gervaz P, Pikarsky A, Utech M, Secic M, Efron J, Belin B, Jain A, Wexner S (2001) Converted laparoscopic colorectal surgery. Surg Endosc 15:827–832. doi:10.1007/s004640080062
2. Schwandner O, Schiedeck TH, Bruch H (1999) The role of conversion in laparoscopic colorectal surgery: do predictive factors exist? Surg Endosc 13:151–156
3. 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, doi:1010.1016/S0140-6736(05)66545-2
4. Neudecker J, Klein F, Bittner R, Carus T, Stroux A, Schwenk W (2009) Short-term outcomes from a prospective randomized trial comparing laparoscopic and open surgery for colorectal cancer. Br J Surg 96:1458–1467. doi:10.1002/bjs.6782
5. Veldkamp R, Kuhry E, Hop WCJ, Jeekel J, Kazemier G, Bonjer HJ, Haglind E, Påhlman 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, doi:10.1016/S1470-2045(05)70221-7
6. Van der Pas MH, Haglind E, Cuesta MA, Fürst A, Lacy AM, Hop WC, Bonjer HJ (2013) Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomised, phase 3 trial. Lancet Oncol 14:210–218. doi:10.1016/S1470-2045(13)70016-0
7. Yamamoto S, Fukunaga M, Miyajima N, Okuda J, Konishi F, Watanabe M (2009) Impact of conversion on surgical outcomes after laparoscopic operation for rectal carcinoma: a retrospective study of 1,073 patients. J Am Coll Surg 208:383–389. doi:10.1016/j.jamcollsurg.2008.12.002
8. Marusch F, Gastinger I, Schneider C, Scheidbach H, Konradt J, Bruch HP, Köhler L, Bärlehner E, Köckerling F (2001) Importance of conversion for results obtained with laparoscopic colorectal surgery. Dis Colon Rectum 44:207–214, discussion 214–6
9. Lord SA, Larach SW, Ferrara A, Williamson PR, Lago CP, Lube MW (1996) Laparoscopic resections for colorectal carcinoma. A three-year experience. Dis Colon Rectum 39:148–154
10. Le Moine M-C, Fabre J-M, Vacher C, Navarro F, Picot M-C, Domergue J (2003) Factors and consequences of conversion in laparoscopic sigmoidectomy for diverticular disease. Br J Surg 90:232–236. doi:10.1002/bjs.4035
11. Belizon A, Sardinha CT, Sher ME (2006) Converted laparoscopic colectomy: what are the consequences? Surg Endosc 20:947–951. doi:10.1007/s00464-005-0553-3
12. Slim K, Pezet D, Riff Y, Clark E, Chipponi J (1995) High morbidity rate after converted laparoscopic colorectal surgery. Br J Surg 82: 1406–1408
13. Ptok H, Kube R, Schmidt U, Köckerling F, Gastinger I, Lippert H (2009) Conversion from laparoscopic to open colonic cancer resection—associated factors and their influence on long-term oncological outcome. Eur J Surg Oncol 35:1273–1279. doi:10.1016/j.ejso.2009.06.006
14. Moloo H, Mamazza J, Poulin EC, Burpee SE, Bendavid Y, Klein L, Gregoire R, Schlachta CM (2004) Laparoscopic resections for colorectal cancer: does conversion survival? Surg Endosc 18:732–735. doi:10.1007/s00464-003-8923-1
15. Ströhlein MA, Grützner K-U, Jauch K-W, Heiss MM (2008) Comparison of laparoscopic vs. open access surgery in patients with rectal cancer: a prospective analysis. Dis Colon Rectum 51: 385–391. doi:10.1007/s10350-007-9178-z
16. Casillas S, Delaney CP, Senagore AJ, Brady K, Fazio VW (2004) Does conversion of a laparoscopic colectomy adversely affect patient outcome? Dis Colon Rectum 47:1680–1685. doi:10.1007/s10350-004-0692-4
17. Rottoli M, Bona S, Rosati R, Elmore U, Bianchi PP, Spinelli A, Bartolucci C, Montorsi M (2009) Laparoscopic rectal resection for cancer: effects of conversion on short-term outcome and survival. Ann Surg Oncol 16:1279–1286. doi:10.1245/s10434-009-0398-4
18. Gonzalez R, Smith CD, Mason E, Duncan T, Wilson R, Miller J, Ramshaw BJ (2006) Consequences of conversion in laparoscopic colorectal surgery. Dis Colon Rectum 49:197–204. doi:10.1007/s10350-005-0258-7
19. Higgins JPT, Thompson SG, Deeks JJ, Altman DG (2003) Measuring inconsistency in meta-analyses. BMJ 327:557–560. doi:10.1136/bmj.327.7414.557
20. Moher D, Liberati A, Tetzlaff J, Altman DG (2010) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Int J Surg 8:336–341. doi:10.1016/j.ijsu.2010.02.007

21. Laurent C, Leblanc F, Wütrich P, Scheffler M, Rullier E (2009) Laparoscopic versus open surgery for rectal cancer: long-term oncologic results. Ann Surg 250:54–61. doi:10.1097/SLA.0b013e3181ad6511
22. Curet MJ, Putrakul K, Pitcher DE, Josloff RK, Zucker KA (2000) Laparoscopically assisted colon resection for colon carcinoma perioperative results and long-term outcome. 1062–1066. doi:10.1007/s004640000092
23. Senagore AJ, Luchtefeld MA, Mackeigan JM, Mazier WP, Lloyd LR, Hoffman JP (1993) Open colectomy versus laparoscopic colectomy—are there differences. Am Surg 59:549–554
24. Begos DG, Arsenault J, Ballantyne GH (1996) Laparoscopic colon and rectal surgery at a VA hospital. Analysis of the first 50 cases. Surg Endosc 10:1050–1056
25. Bouvet M, Mansfield PF, Skibber JM, Curley SA, Ellis LM, Giacco GG, Madary AR, Ota DM, Feig BW (1998) Clinical, pathologic, and economic parameters of laparoscopic colon resection for cancer. Am J Surg 176:554–558
26. Kaiser AM, Kang J-C, Chan LS, Vukasin P, Beart RW (2004) Laparoscopic-assisted vs. open colectomy for colon cancer: a prospective randomized trial. J Laparoendosc Adv Surg Tech A 14: 329–334. doi:10.1089/lap.2004.14.329
27. Hewett PJ, Allardyce RA, Bagshaw PF, Frampton CM, Frizelle FA, Rieger NA, Smith JS, Solomon MJ, Stephens JH, Stevenson ARL (2008) Short-term outcomes of the Australasian randomized clinical study comparing laparoscopic and conventional open surgical treatments for colon cancer: the ALCCaS trial. Ann Surg 248:728–738. doi:10.1097/SLA.0b013e31818b7595
28. Martinek L, Dostalik J, Gunkova P, Gunka I, Vavra P, Zonca P (2012) Impact of conversion on outcome in laparoscopic colorectal cancer surgery. Videosurgery Other Miniinvasive Tech 7:74–81. doi:10.5114/wiitm.2011.25799
29. Rottoli M, Stocchi L, Geisler DP, Kiran RP (2012) Laparoscopic colorectal resection for cancer: effects of conversion on long-term oncologic outcomes. Surg Endosc 26:1971–1976. doi:10.1007/s00464-011-2137-8
30. Mroczkowski P, Hac S, Smith B, Schmidt U, Lippert H, Kube R (2012) Laparoscopy in the surgical treatment of rectal cancer in Germany 2000–2009. Color Dis 14:1473–1478. doi:10.1111/j.1463-1318.2012.03058.x
31. Penninckx F, Kartheuser A, Van de Stadt J, Pattyn P, Mansvelt B, Bertrand C, Van Eycken E, Jegou D, Fieuws S (2013) Outcome following laparoscopic and open total mesorectal excision for rectal cancer. Br J Surg 100:1368–1375. doi:10.1002/bjs.9211
32. Kang CY, Halabi WJ, Chaudhry OO, Nguyen V, Ketana N, Carmichael JC, Pigazzi A, Stamos MJ, Mills S (2013) A nationwide analysis of laparoscopy in high-risk colorectal surgery patients. J Gastrointest Surg 17:382–391. doi:10.1007/s11605-012-2096-y
33. Kolfschoten NE, van Leersum NJ, Gooiker GA, Marang van de Mheen PJ, Eddes EH, Kievit J, Brand R, Tanis PJ, Bemelman WA, Tollenaar RA, Meijerink J, Wouters MW (2013) Successful and safe introduction of laparoscopic colorectal cancer surgery in Dutch hospitals. Ann Surg 257:916–921. doi:10.1097/SLA.0b013e31825d0f37
34. Rickert A, Herrle F, Doyon F, Post S, Kienle P (2013) Influence of conversion on the perioperative and oncologic outcomes of laparoscopic resection for rectal cancer compared with primarily open resection. Surg Endosc 27:4675–4683. doi:10.1007/s00464-013-3108-z
35. Taylor EF, Thomas JD, Whitehouse LE, Quirke P, Jayne D, Finan PJ, Forman D, Wilkinson JR, Morris EJ (2013) Population-based study of laparoscopic colorectal cancer surgery 2006–2008. Br J Surg 100:553–560. doi:10.1002/bjs.9023
36. Koo H, Kim H, Yun S, Lee W, Cho Y, Park Y, Yun J, Kim K (2013) Comparison of short-term and long-term outcomes in open surgery group, laparoscopic surgery group and conversion to open surgery group during laparoscopic colorectal cancer surgery. Dis Colon Rectum 56:E272
37. Jayne DG, Thorpe HC, Copeland J, Quirke P, Brown JM, Guillou PJ (2010) Five-year follow-up of the Medical Research Council CLASICC trial of laparoscopically assisted versus open surgery for colorectal cancer. Br J Surg 97:1638–1645. doi:10.1002/bjs.7160
38. Bhama AR, Charlton ME, Schmitt MB, Cromwell JW, Byrn JC (2014) Factors associated with conversion from laparoscopic to open colectomy using the National Surgical Quality Improvement Program (NSQIP) database. Color Dis. doi:10.1111/codi.12800
39. Masoomi H, Moghadamyeghaneh Z, Mills S, Carmichael JC, Pigazzi A, Stamos MJ (2015) Risk factors for conversion of laparoscopic colorectal surgery to open surgery: does conversion worsen outcome? World J Surg. doi:10.1007/s00268-015-2958-z
40. Cima RR, Hassan I, Poola VP, Larson DW, Dozois EJ, Larson DR, O'Byrne MM, Huebner M (2010) Failure of institutionally derived predictive models of conversion in laparoscopic colorectal surgery to predict conversion outcomes in an independent data set of 998 laparoscopic colorectal procedures. Ann Surg 251:652–658. doi:10.1097/SLA.0b013e3181d355f7

Publication n. 3

Celentano, V., Finch, D., Forster, L., Robinson, J.M., Griffith, J.P. (2015). Safety of supervised trainee performed laparoscopic surgery for inflammatory bowel disease. *Int J Colorectal Dis* (2015) May; 30:639-44

Int J Colorectal Dis (2015) 30:639–644
DOI 10.1007/s00384-015-2147-4

ORIGINAL ARTICLE

Safety of supervised trainee-performed laparoscopic surgery for inflammatory bowel disease

Valerio Celentano · David Finch · Luke Forster · Jonathan M. Robinson · John P. Griffith

Accepted: 23 January 2015 / Published online: 12 February 2015

Abstract
Purpose There is a significant risk of surgical resection during the lifetime of an inflammatory bowel disease (IBD) patient: laparoscopic surgery has been increasingly applied to the management of IBD with short and long-term advantages. The aim of this study is to demonstrate that laparoscopic surgery for IBD, performed by a surgical trainee under the supervision of an experienced trainer, is feasible and safe.
Methods All surgical procedures were sub-divided in six critical steps in order to define the procedure as supervised trainee performed (STP) when the trainer was present unscrubbed in the theatre or assisting and trainer performed (TNER) when the trainer performed two or more critical steps of the procedure. Included were all patients undergoing laparoscopic resection for IBD between January 2009 and December 2013. Thirty-day mortality and morbidity were the primary outcomes. Reoperations and rehospitalizations within 30 days of discharge were recorded prospectively and were the secondary outcomes together with conversion rate and length of hospital stay.
Results One hundred fifty-one patients were included: 77 (50.99 %) STP and 74 (49.01 %) TNER. No deaths occurred, and 30-day morbidity was 27.15 % with no differences between the groups. Operating time was longer in the STP (166.6±53.31 vs 130.4±49.15). Five patients (2 vs 3) required reoperation (3.31 %), while 13 patients (8.6 %) required readmission.
Conclusions Laparoscopic surgery for IBD performed by a supervised trainee is safe compared to trainers performed procedures despite a longer operating time. Randomized clinical trials are needed to confirm these preliminary results and to investigate long-term outcomes.

Keywords Inflammatory bowel disease · Laparoscopic colorectal surgery · Surgical training · Trainee-performed surgery

V. Celentano (✉) · D. Finch · L. Forster · J. M. Robinson · J. P. Griffith
Colorectal Unit, Bradford Royal Infirmary, Bradford, UK
e-mail: valeriocelentano@yahoo.it

Introduction

Despite many advances in the medical management of inflammatory bowel disease (IBD), there is still a significant risk of surgical resection during the lifetime of a patient. Approximately 20–35 % of patients with ulcerative colitis (UC) will require surgery, whereas up to 70–80 % of Crohn's disease (CD) patients will undergo one or more resections during their lifetime [1, 2].

Laparoscopic surgery has been increasingly applied to the management of IBD in the last 15 years [3]. Short-term advantages of laparoscopic colorectal resections (LCR) include faster return of bowel function, faster recovery time, shorter hospital stay and reduced requirement for analgesics [4, 5].

Meta-analyses of previous studies have suggested that laparoscopic surgery is comparable to open surgery in short-term complication rates [6], and it has been shown that patients undergoing LCR return earlier to their normal activities [7]. A reduced number of incisional hernias and fewer adhesions are the long-term advantages of laparoscopy in IBD and make this approach logically favourable for patients susceptible to undergoing several surgical interventions [8, 9].

Several aspects of IBD like a thickened and friable mesentery, enteric fistulas, bowel perforation and frequent occurrence of intra-abdominal abscesses and adhesions make LCR technically demanding [10]. These difficulties are reflected in the high rate of conversions and complications after surgical treatment of IBD [11] and raise questions on the suitability for surgical trainees to perform such complex surgery and whether it is appropriate to consider LCR for IBD good training cases.

A number of studies have reported on the length of the learning curve for LCR by using different methods and end points resulting in suggested numbers between 11 and 110 cases [12]. This heterogeneity is easily explained by the different parameters used for evaluating the learning curve such as conversion rate, operating time, blood loss and rate of postoperative complications [13].

The average length of the proficiency gain curve in LCR for self-taught senior surgeons is estimated between 100 and 150 procedures [14]. Supervised training programs have demonstrated to significantly decrease the length of the learning curve [15], and an autodidactic approach to acquire the necessary skills for LCR should be considered obsolete and unacceptable.

The aim of this observational study is to demonstrate that laparoscopic surgery performed by a surgical trainee under the direct supervision of an experienced trainer is feasible and safe even in challenging cases. In the present study, we analyse the short-term outcomes of LCR for IBD performed by a supervised surgical trainee over a period of time of 5 years at a tertiary referral centre.

Patients and methods

Study setting

All surgical procedures were sub-divided in six different critical steps in order to define the procedure as supervised trainee performed (STP) when the trainer was present unscrubbed in the theatre or assisting and trainer performed (TNER) when the trainer performed two or more critical steps of the procedure (Table 1). The operative steps were prospectively recorded in each procedure.

All the trainees were in the last 3 years of their specialist surgical training, and all of them had previously performed no more than 15 LCR. Our department is a tertiary referral unit for colorectal surgery and a nationally recognized training centre for laparoscopic colorectal surgery: two trainers with more than 8 years experience in LCR were involved in all the procedures.

Table 1 Six critical steps of laparoscopic colorectal resections

1. Theatre setup and laparoscopic access[a]
2. Dissection and division of the vascular pedicle
3. Mobilization of the colon
4. Bowel division
5. Extraction of specimen
6. Anastomosis[b]

[a] Patient positioning, induction of the pneumoperitoneum, division of adhesions if necessary and exposure of the operative field

[b] When no anastomosis was performed, the formation of the stoma was counted as anastomosis

Patient selection

Included were all consecutive patients undergoing LCR for IBD in the 5-year period between January 2009 and December 2013: these cases of histologically confirmed UC, CD or indeterminate colitis were prospectively entered into a database. Cases complicated by cancer, toxic megacolon, peritonitis and acute small bowel obstruction were excluded, as were all the procedures performed in single incision laparoscopic surgery (SILS). All ileal pouch anal anastomoses (IPAA) were excluded because the procedure is routinely performed through a lower midline incision in our unit.

Prior to surgery all cases were regularly discussed by the dedicated multidisciplinary team.

Data collection and outcome analysis

Preoperative, operative and postoperative data were prospectively recorded for each patient of both groups. Preoperative parameters included age, sex, body mass index (BMI), comorbidities, American Society of Anesthesiologists (ASA) status, albumin and haemoglobin concentration, previous abdominal surgery (appendectomy via McBurney incision was not counted), smoking status, weight loss, indication for surgery and preoperative medical therapy.

Operative data included duration of surgery, intraoperative complications, estimated operative blood loss, type of incision for specimen retrieval, reasons for conversion and use of temporary ileostomy. Postoperative data included postoperative length of hospital stay (LOS), time to tolerate oral fluids and oral diet, time to resolution of ileus and postoperative complications according to the Dindo–Clavien classification [16].

Thirty-day mortality and 30-day morbidity were the primary outcomes. Reoperations and rehospitalizations within 30 days of hospital discharge were recorded prospectively and were the secondary outcomes together with conversion rate and LOS.

Surgical technique and postoperative management

Surgery was performed according to established techniques and was the same in both treatment groups. In all laparoscopic ileocecal resections, the mesentery division and stapled functional end-to-end anastomosis were performed intracorporeally.

All the cases of subtotal colectomy (STC) were performed with a five trocar technique using a right-to-left approach: the superior rectal artery was preserved in all cases. The specimen was retrieved through a right iliac fossa incision, and the procedure was concluded with the formation of a terminal ileostomy. Proctectomy was performed according to the total mesorectal excision technique, and the specimen was delivered through the perineal incision. Intra-abdominal drainage was not routinely used while a Foley catheter remained in place in the rectal stump for 3 to 5 days in all STC. Postoperatively, all patients were managed according to a structured rehabilitation-enhanced recovery program involving physiotherapists, dieticians, and nurse clinicians in a standardized clinical pathway. Patients were followed up in colorectal clinics postoperatively.

Definitions

Steroid use was defined as corticosteroids administered within 1 month prior to surgery, while immunosuppressive use was defined as azathioprine or 6-mercaptopurine used within 2 months prior to surgery. Anti-TNF monoclonal antibody use was defined as the last infusion of infliximab within 12 weeks prior to surgery. Active smoking status was defined as smoking within 1 year before surgery, and weight loss was defined as more than 5 kg in the previous 6 months.

Duration of the operation was defined as time from skin incision to wound closure. Conversion was defined as the need for an unplanned laparotomy or extension of the initial extraction site to achieve anything else other than specimen extraction or stoma formation. Mortality was defined as death occurring in the hospital or within 30 days from discharge. Postoperative morbidity was defined as complications occurring in the hospital or within 30 days after surgery.

Statistical analysis

Categorical variables are presented as frequency or percentage and were compared with the use of the chi-square test or Fisher's exact test, as appropriate. Continuous variables are presented as means (±standard deviation) and were compared with the use of Student's *t* test. The Mann–Whitney *U* test was used for continuous, not normally distributed, outcomes.

To test the presence of potential confounding factors, we analysed the impact of the level of the surgeon (supervised trainee vs trainer) on postoperative morbidity in a multivariable logistic regression model, considering also age, sex, ASA grade, BMI, emergency setting, indication for surgery, previous abdominal surgery, conversion and operating time.

Statistical analysis was performed by using the Statistical Package for the Social Sciences (SPSS version 16.0; SPSS, Chicago, IL, USA). All reported *P* values were two-tailed, and *P* values of less than 0.05 were considered to indicate statistical significance.

Results

Two hundred twenty-three patients were identified. After excluding 49 patients who underwent IPAA, 8 SILS, 5 peritonitis, 2 cancer operations, 2 diagnostic laparoscopies, 2 laparoscopic-assisted formation of colostomy, 2 toxic megacolon and 2 stricturoplasty, finally 151 patients were included in the study.

Seventy-seven patients (50.99 %) were operated by supervised trainees (STP) and 74 (49.01 %) by the trainers (TNER). Preoperative characteristics were comparable in the two groups and are shown in Table 2. Surgical procedures are detailed in Table 3. All patients who underwent right hemicolectomy had a primary anastomosis except for one patient in STP who was treated with an end ileostomy because of intra-abdominal contamination.

Table 2 Patients characteristics

	STP (n=77)	TNER (n=74)	p value
Age (years) (mean±SD)	41.48±11.7	40.28±14.14	ns
Sex (male/female)	44/33	49/35	ns
BMI (Kg/m^2) (mean±SD)	24.63±3.67	25.22±3.07	ns
ASA status			
I	29 (37.66 %)	20 (27.02 %)	ns
II	41 (53.24 %)	43 (58.1 %)	ns
III	7 (9.09 %)	10 (12.98 %)	ns
IV	0	1 (1.35 %)	ns
Alb (g/L) (SD)	33.2±5.43	32.91±6.04	ns
Hb (g/L) (SD)	107.24±12.08	112±21.45	ns
Elective/emergency	61/16	55/19	ns
Indication for surgery			
UC	35 (45.45 %)	34 (45.94 %)	ns
CD	41 (53.24 %)	38 (51.35 %)	ns
Stricture	26	20	ns
Abscess	4	3	ns
Fistula	4	7	ns
Colitis	7	8	ns
Indeterminate colitis	1 (1.29 %)	2 (2.7 %)	ns
Previous surgery	15 (19.48 %)	20 (27.02 %)	ns
Smoking	18 (23.37 %)	24 (32.43 %)	ns
Weight loss	23 (29.87 %)	21 (28.37 %)	ns
Medical therapy			
Steroids	38 (49.35 %)	41 (55.4 %)	ns
Immunosuppressor	29 (37.66 %)	26 (35.13 %)	ns
Anti-TNF	27 (35.06 %)	20 (27.02 %)	ns

ns not statistically significant, *SD* standard deviation, *BMI* body mass index=weight/(height)^2, *ASA* American Society of Anesthesiologist, *Alb* albumin, *Hb* haemoglobin, *UC* ulcerative colitis, *CD* Crohn's disease, *TNF* tumour necrosis factor

Table 3 Surgical procedures

	STP (n=77)	TNER (n=74)	p value
RH	34 (44.15 %)	30 (40.54 %)	ns
Proctectomy	7 (9.09 %)	11 (14.86 %)	ns
STC	36 (46.75 %)	33 (44.59 %)	ns

STP Supervised trainee performed, *TNER* trainer performed, *ns* not statistically significant, *RH* right hemicolectomy, *STC* subtotal colectomy

Morbidity, mortality and reoperations

No deaths occurred within 30 days of operation.

The overall 30-day morbidity rate was noted to be 27.15 % (Table 4), and overall, five patients (2 STP 2.59 % vs 3 TNER 4.05 %) required reoperation (3.31 %) with no differences between the two groups. In STP group, 22 patients (28.57 %) had 29 complications: 1 grade I, 18 grade II, 6 grade III and 4 grade IV according to Clavien-Dindo classification. Five patients developed an intra-abdominal collection: three required CT-guided drainage, one laparotomy and washout and one long-term antibiotics. Two patients out of 33 (6.06 %) who underwent ileocolic resections and primary anastomosis developed anastomotic leak: one was treated conservatively while the other required a laparotomy and formation of end ileostomy.

In the TNER group, 19 patients (25.67 %) had 27 complications: 2 grade I, 17 grade II, 4 grade III and 3 grade IV according to Clavien-Dindo classification. Three patients required reoperation: one port site hernia repair, one laparotomy and evacuation of haematoma and one laparotomy and small bowel resection for enterocutaneous fistula. The multivariable logistic regression analysis, taking into consideration potential confounding variables, confirmed that the level of the operating surgeon (supervised trainee vs trainer) had no influence on the postoperative outcome (Table 5).

Table 4 Thirty-day morbidity

Complication	STP (n=77)	TNER (n=74)	p value
Ileus	6 (7.79 %)	4 (5.4 %)	ns
Intra-abdominal collection	5 (6.49 %)	4 (5.4 %)	ns
Pneumonia	2 (2.59 %)	5 (6.75 %)	ns
Wound infection	2 (2.59 %)	4 (5.4 %)	ns
Mechanical SBO	2 (2.59 %)	3 (4.05 %)	ns
UTI	3 (3.89 %)	0 (0 %)	ns
DVT	1 (1.29 %)	1 (1.35 %)	ns
Rectal stump leak[a]	1 (2.77 %)	1 (3.03 %)	ns
Sepsis	2 (2.59 %)	2 (2.7 %)	ns
Bleeding	1 (1.29 %)	1 (1.35 %)	ns
Anastomotic leak[b]	2 (6.06 %)	0 (0 %)	ns
Other[c]	2 (2.59 %)	2 (2.7 %)	ns
Total	29 (37.66 %)	27 (36.48 %)	ns

STP supervised trainee performed, *TNER* trainer performed, *SBO* small bowel obstruction, *UTI* urinary tract infection, *DVT* deep vein thrombosis

[a] Thirty-six patients in STP and 33 patients in TNER had a subtotal colectomy

[b] Thirty-three patients in STP and 30 patients in TNER had a primary anastomosis

[c] Adrenal insufficiency and acute myocardial infarction in STP, port site hernia and enterocutaneous fistula in TNER

Operating time, blood loss and conversion rate

Mean operating time was slightly longer in the STP than TNER (166.6±53.31 vs 130.4±49.15 min, $p<0.0001$). Procedure-specific data are shown in Fig. 1. No statistical difference was noted in estimated intraoperative blood loss. Overall, six procedures were converted (3.97 %): 2 STP vs 4 TNER.

Hospital stay and readmissions

LOS was 8.35±7.57 and 7.78±6.78 days (p=0.6346) in STP and TNER, respectively. Procedure-specific data are shown in Fig. 2.

Overall, 13 patients (8.6 %) required readmission within 30 days of discharge. There was no difference in the two groups, and none of the patients required reintervention during the second admission. In the STP group, seven patients (9.09 %) were readmitted: one for intra-abdominal collection, two for pneumonia, three for mechanical small bowel obstruction resolved with conservative management and one for perineal pain.

In the TNER group, six patients (8.1 %) were readmitted: one for intra-abdominal collection, two for pneumonia, one for mechanical small bowel obstruction treated conservatively, one for abdominal pain and one for stoma management.

Table 5 Univariable and multivariable logistic regression analysis of patients with and without postoperative complications

	Univariable p	Multivariable p
Age	0.84	0.83
Sex	0.56	0.66
ASA grade	0.59	0.88
BMI	0.98	0.88
Setting (emergency/elective)	0.63	0.71
Indication (CD/UC)	0.63	0.78
Conversion to open	0.98	0.93
Previous surgery (yes/no)	0.62	0.60
Operating time	0.62	0.86
Surgeon (trainee/trainer)	0.29	0.28

ASA American society of Anesthesiologist, *BMI* body mass index, *CD* Crohn's disease, *UC* ulcerative colitis

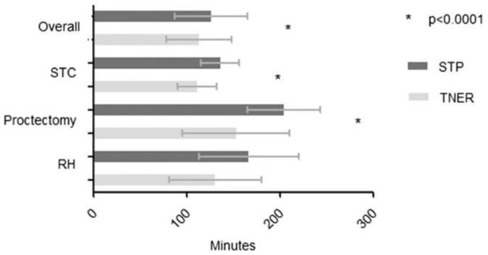


Fig. 1 Overall and procedure-specific operating time (mean±SD). *STP* supervised trainee performed, *TNER* trainer performed, *STC* subtotal colectomy, *RH* right hemicolectomy

Discussion

Despite increasing evidence for the clinical benefits of LCR and its safety [17], the dissemination of this technique has been slow; one of the main constraints for a swift uptake is a prolonged learning curve [18].

Tekkis et al. [12] demonstrated a learning curve of 55 cases for right-sided colonic resection vs 62 cases for left-sided resections using a risk-adjusted cumulative sum (CUSUM) model with conversion rate as a dependent variable.

Increased rates of adverse clinical outcomes at the early stage of the learning curve raise ethical questions and highlight the need for mechanisms to reduce complications and conversions during the initial stage of independent practice. Our study showed no difference in 30-day morbidity and 30-day mortality in the group of patients operated by a supervised surgical trainee compared to the trainer-performed procedures.

Relatively high rates of mortality and septic complications have been reported in patients who undergo resections for IBD; the rate of intra-abdominal sepsis and anastomotic leakage after resection for CD has been reported up to 14 and 17 %, respectively [19], while a complication rate from 16 to 37 % has been reported after surgery for UC in a systematic review including a total of 2714 patients [14]. No death occurred in our study population; 30 day morbidity was 27.15 % (28.57 % in STP vs 25.67 % in TNER) and reoperation rate was 3.31 % (2.59 % in STP vs 4.05 % in TNER). In 63 patients, an anastomosis was performed (33 in STP VS 30 in TNER) and there were 2 anastomotic leaks (3.17 %).

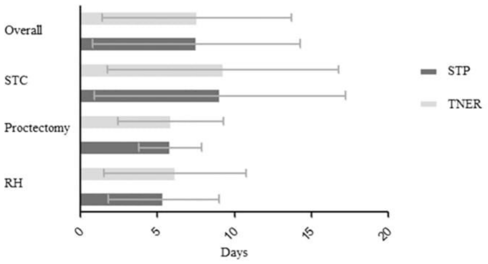


Fig. 2 Overall and procedure-specific length of hospital stay (mean± SD). *STP* supervised trainee performed, *TNER* trainer performed, *STC* subtotal colectomy, *RH* right hemicolectomy

There was no difference in the conversion rate in between the two groups of the study. The population of this study has not been randomized, and there could obviously be a selection bias in our groups, potentially resulting in the trainers performing the most complex cases and taking over operating cases that were too difficult for the trainees. However, there were no differences in BMI, ASA status, previous surgery and preoperative medical therapy between the two groups. Not surprisingly, statistically significant difference was found in the operating time: STC, proctectomy and overall operating time were longer in the STP.

Our study aims to address the question whether the outcomes of the procedure differ on the basis of who performs the operation. It is important to consider that patient safety must never be compromised; therefore, it is hard to imagine a surgeon watching a trainee getting into trouble without intervening. Prospectively recording who performed each of the six critical steps of the procedure is an attempt to minimize this intrinsic bias. However, this study analyses the outcomes of laparoscopic surgery performed by a supervised trainee and not an independent trainee: this is fairly critical. The presence in theatre or at the operating table of the trainer makes obviously a significant difference, and this is what we exactly aim in a national training unit.

In our study, an interestingly high rate of patients with history of previous open abdominal surgery underwent laparoscopic resections (23.17 %). This trend towards inclusion of difficult and complex LCR without compromising results in highly specialized units is in keeping with the findings of Marusch et al. [20] who demonstrated in a multicentre study of 1658 patients that surgeons with more than 100 LCR are likely to embark upon more technically demanding operations without any increase in complications and mortality with a conversion rate of 4.3 % compared to 6.9 % in those with less than 100 cases experience.

LCR is technically complex, and some aspects of IBD make it even more challenging. None of the trainees involved in the present study had performed more than 15 LCR previously. The acceptable rates of complications, intraoperative blood loss and conversion rate in a supervised setting could reflect the effectiveness of nationally recognized training programs and post-training fellowships in order to shorten the learning curve: despite a longer operating time, our study demonstrates the safety of complex trainee-performed LCR when supervised by an experienced colorectal trainer.

Conclusions

LCR for IBD performed by a surgical trainee in a supervised setting is safe compared to trainer-performed procedures. Randomized clinical trials are needed to confirm these preliminary results and to investigate long-term outcomes.

Conflict of interest The authors declare no conflict of interest.

Authors' contributions Valerio Celentano was responsible for the conception and design of the study, analysis and interpretation of data, article drafting and review; David Finch was responsible for the acquisition of data and drafting the article; Luke Forster was responsible for the acquisition of data and drafting the article; Jonathan Robinson did the acquisition, analysis and interpretation of data and article review; and John Griffith did the conception and design of the study and article review.

References

1. Milsom JW (2005) Laparoscopic surgery in the treatment of Crohn's disease. Surg Clin N Am 85:25–34
2. Hasegawa H, Watanabe M, Nishibori H et al (2003) Laparoscopic surgery for recurrent Crohn's disease. Br J Surg 90:970–973
3. Maggiori L, Khayat A, Treton X et al (2014) Laparoscopic approach for inflammatory bowel disease is a real alternative to open surgery: an experience with 574 consecutive patients. Ann Surg 260(2):305–310
4. Rosman AS, Melis M, Fichera A (2005) Metaanalysis of trials comparing laparoscopic and open surgery for Crohn's disease. Surg Endosc 19:1549–1555
5. Tan JJ, Tjandra JJ (2006) Laparoscopic surgery for ulcerative colitis: a meta-analysis. Colorectal Dis 8:626–636
6. Tan JJY, Tjandra JJ (2007) Laparoscopic surgery for Crohn's disease: a meta-analysis. Dis Colon Rectum 50:576–585
7. Braga M, Vignali A et al (2002) Laparoscopic versus open colorectal surgery: a randomised trial on short-term outcome. Ann Surg 236: 759–766
8. Indar AA, Efron JE, Young-Fadok TM (2009) Laparoscopic ileal pouch-anal anastomosis reduces abdominal and pelvic adhesions. Surg Endosc 23:174–177
9. Taylor GW, Jayne DG, Brown SR et al (2010) Adhesions and incisional hernias following laparoscopic versus open surgery for colorectal cancer in the CLASICC trial. Br J Surg 97:70–78
10. Schlachta CM, Mamazza J, Seshadri PA et al (2001) Defining a learning curve for laparoscopic resections. Dis Colon Rectum 44: 217–222
11. Lu KC, Cone MM, Diggs BS et al (2011) Laparoscopic converted to open colectomy: predictors and outcomes from the Nationwide Inpatient Sample. Am J Surg 201(5):634–639
12. Tekkis PP, Senagore AJ, Delaney CP et al (2005) Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. Ann Surg 242:83–91
13. Barrie J, Jayne DG, Wright J et al (2014) Attaining surgical competency and its implications in surgical clinical trial design: a systematic review of the learning curve in laparoscopic and robot-assisted laparoscopic colorectal cancer surgery. Ann Surg Oncol 21:829–840
14. Miskovic D, Ni M, Wyles SM, Tekkis PP, Hanna GB (2012) Learning curve and case selection in laparoscopic colorectal surgery: systematic review and international multicenter analysis of 4852 cases. Dis Colon Rectum 55(12):1300–1310
15. Mackenzie H, Miskovic D, Ni M et al (2013) Clinical and educational proficiency gain of supervised laparoscopic colorectal surgical trainees. Surg Endosc 27(8):2704–2711
16. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240:205–213
17. Teeuwen PH, Stommel MW, Bremers et al (2009) Colectomy in patients with acute colitis: a systematic review. J Gastrointest Surg 13:678–686
18. Hewett PJ, Allardyce RA, Bagshaw PF et al (2008) Short-term outcomes of the Australasian randomized clinical study comparing laparoscopic and conventional open surgical treatments for colon cancer: the ALCCaS trial. Ann Surg 248:728–738
19. Yamamoto T, Allan RN, Keighley MR (2000) Risk factors for intra-abdominal sepsis after surgery in Crohn's disease. Dis Colon Rectum 43:1141–1145
20. Marusch F, Gastinger I, Schneider C et al (2001) Importance of conversion for results obtained with laparoscopic colorectal surgery. Dis Colon Rectum 44:207–214

Publication n. 4

Celentano, V., Sagias, F., Flashman, K., Conti, J., Khan, J. (2019). Laparoscopic redo ileocolic resection for Crohn's disease in patients with previous multiple laparotomies. *Scand J Su*rg. 2019 Mar;108(1):42-48.

Original Research Article

SJS
SCANDINAVIAN
JOURNAL OF SURGERY

LAPAROSCOPIC REDO ILEOCOLIC RESECTION FOR CROHN'S DISEASE IN PATIENTS WITH PREVIOUS MULTIPLE LAPAROTOMIES

V. Celentano, F. Sagias, K. G. Flashman, J. Conti, J. Khan

Colorectal Unit, Queen Alexandra Hospital, Portsmouth Hospitals NHS Trust, Portsmouth, UK

ABSTRACT

Purposes: **Over 80% of patients with primary ileocolic Crohn's disease have a surgical resection within 10 years of diagnosis, and 40%–50% of them need further surgery within 15 years. Laparoscopic surgery can be challenging due to a thickened mesentery and the potential for fistulas, abscesses, and phlegmons. Aim of this study is to analyze the short-term outcomes of laparoscopic redo ileocolic resections for Crohn's disease in patients with previous multiple laparotomies.**

Methods: **All patients undergoing laparoscopic surgery for ileocolic Crohn's disease from March 2006 to February 2017 were prospectively evaluated. Short term outcomes of laparoscopic ileocolic resection were compared between patients with previous multiple major surgeries and recurrent Crohn's disease, and patients undergoing surgery for the first presentation of Crohn's disease and no history of previous surgery. Conversion rate and 30-day morbidity were the primary outcomes. Reoperations, readmissions, operating time and length of stay were the secondary outcomes.**

Results: **29 patients with recurrent Crohn's disease and previous multiple laparotomies were included: the number of laparotomies these patients previously underwent was 2 in 19 cases (65.5%), 3 in 9 (31%), and 4 in 1 (3.5%). In total, 90 patients with no history of any previous abdominal surgery, who underwent laparoscopic ileocecal resection for Crohn's disease, represented the control group. No differences were found in morbidity and conversion rate. Operating time was longer in patients with history of previous abdominal surgery.**

Conclusion: **Laparoscopic redo ileocolic resection for Crohn's disease is feasible and safe in patients with previous multiple laparotomies at the expense of longer operating time.**

Key words: Crohn's disease; laparoscopic colorectal surgery; ileocecal resection; redo surgery

Correspondence:
Valerio Celentano, MD, FRCS
Colorectal Unit
Queen Alexandra Hospital
Portsmouth Hospitals NHS Trust
Southwick Hill
Portsmouth PO6 3AD
UK
Email: valeriocelentano@yahoo.it

Scandinavian Journal of Surgery
1–7

Reprints and permissions:
sagepub.co.uk/journalsPermissions.nav
DOI: 10.1177/1457496918772370
journals.sagepub.com/home/sjs
SAGE

INTRODUCTION

Despite many advances in the medical management of Crohn's disease (CD), there is still a significant risk of surgical resection for failure of medical management or complications during the lifetime of a patient (1).

Although the patterns of disease within the gastrointestinal tract are varied, the most commonly affected areas are the terminal ileum and cecum (55%). Other areas include small bowel disease only (11%–48%), colon disease only (19%–51%), and combined small and large intestine (26%–48%) (2).

Over 80% of patients diagnosed with primary ileocolic CD, who are typically young adults, have a surgical resection within 10 years of their diagnosis (3). Of these, 30%–50% will have symptomatic recurrence of disease during the first 5 years and 50%–80% by 10 years after surgery (4). Approximately, 40%–50% of patients undergoing surgery for CD are likely to need further operations within 10–15 years (5).

The advent of laparoscopic surgery has dramatically changed the landscape of colorectal surgery for both benign and malignant disease. When compared with traditional open surgery, laparoscopy offers well-described benefits (6) such as decreased pain, lower wound complication rates, improved pulmonary function, earlier resumption of diet and bowel function, better cosmesis, and shorter hospital stays (7). However, widespread use of laparoscopy in inflammatory bowel disease has been more limited due to technical constraints: the inflammation encountered in CD is often multifocal and makes a minimally invasive approach challenging due to a thickened mesentery, as well as the potential for fistulas, abscesses, and large phlegmons (8, 9); moreover, the lack of tactile feedback potentially limits the identification of occult disease.

As a consequence, a substantial number of patients with complicated CD have been traditionally denied an initial laparoscopic approach until recently. Similarly, the feasibility and safety of laparoscopy surgery for recurrent CD, particularly at the ileocolic anastomosis, has been debated: arguments for this approach include both the inherent technical challenge and the higher incidence of postoperative septic complications that can reach 50% in patients with multiple additive risk factors such as chronic steroid use, low albumin level, and presence of abscesses and fistulas (10). The aim of this prospective observational study is to analyze the short-term outcomes of laparoscopic redo ileocolic resections for CD in patients with previous multiple laparotomies, addressing the question on the feasibility of laparoscopic surgery in the hostile abdomen, which has traditionally been considered a relative contraindication to a minimally invasive approach.

METHODS

STUDY OBJECTIVES

To compare the short-term outcomes of laparoscopic ileocolic resection in (1) patients with recurrent CD of the distal ileum and previous multiple laparotomies (MPL—group A) versus (2) patients with first presentation of ileocolic CD and no previous abdominal surgery (NPS—group B).

STUDY DESIGN

All patients undergoing laparoscopic surgery for ileocolic CD from 1 March 2006 to 28 February 2017 were included in this prospective observational study. All patients undergoing open, single-incision, robotic or hand-assisted surgery for ileocolic CD were excluded as were patients undergoing emergency operations.

In order to assess the feasibility of a laparoscopic approach even in complex recurrent CD, patients with previous multiple major surgeries were compared with patients undergoing surgery for CD for the first time and with no history of any previous abdominal operation.

Group A—MPL included patients with recurrent ileocolic CD and history of two or more previous laparotomies. A previous laparotomy was defined as an open surgical procedure which required a midline abdominal incision. Laparoscopic procedures such as appendectomies, cholecystectomies, and diagnostic laparoscopies were not counted as previous surgery as was an appendectomy performed via a McBurney incision or a cesarean section via a Pfannenstiel incision.

The MPL cases were compared to a control group represented by all patients who underwent surgery for first presentation of ileocolic CD and no history of any previous abdominal surgery (group B—NPS). Strict criteria were decided for inclusion in the control group, and patients were excluded even if they only had minor laparoscopic procedures, such a diagnostic laparoscopy or a laparoscopic appendectomy.

The indication for surgical resection was discussed at a dedicated inflammatory bowel disease (IBD) multidisciplinary team (MDT) meeting involving gastroenterologists, colorectal surgeons, radiologists, and pathologists. Preoperative assessment included colonoscopy, magnetic resonance imaging (MRI) enterography, and intestinal ultrasound.

DATA COLLECTION

Preoperative, operative, and postoperative data were prospectively recorded for each patient in both groups. Preoperative parameters included age, sex, body mass index (BMI), comorbidities, American Society of Anesthesiologists (ASA) status, albumin and hemoglobin concentration, smoking status, weight loss, indication for surgery, and preoperative medical therapy.

Operative data included duration of surgery, intraoperative complications, estimated operative blood loss, type of incision for specimen retrieval, conversion rate, reason for conversion, and use of temporary ileostomy. Postoperative data included length of hospital stay (LOS), time to tolerate oral fluids and oral diet, and time to resolution of ileus and postoperative complications according to the Dindo–Clavien classification (11).

PRIMARY AND SECONDARY OUTCOMES

As we did not expect a difference in mortality, data on morbidity and feasibility of the laparoscopic approach have been the key outcome measures in the comparison. Conversion rate and 30-day morbidity were the primary outcomes.

The secondary outcomes were operating time, LOS, reoperations, and rehospitalization within 30 days and were recorded prospectively.

SURGICAL TECHNIQUE

In reoperative surgery the sites of previous abdominal incisions are marked and the first trocar is inserted via an open Hassan technique away from the midline, alternatively an optical trocar access in the left upper quadrant may be utilised. The abdominal cavity is inspected and preliminary division of adhesions is often necessary and performed with cold sharp dissection. This is followed by a complete mobilization of the terminal ileum and right colon and hepatic flexure and mobilization of the small bowel mesentery up to the duodenum. The recurrence is usually at the ileocolic anastomosis and that area is approached last. Hepatic flexure and terminal ileum are mobilized first. Placing a 5-mm camera through the suprapubic port can usually give a very good view of the phlegmon and retroperitoneal structures allowing a safer dissection. When adequate mobilization has been obtained, the bowel is exteriorized through a 4- to 5-cm midline incision that may need to be extended to exteriorize larger terminal ileal phlegmons. This provides excellent exposure of the usually thickened mesentery, which is systematically divided using an overlapping Kocher clamp technique. In our experience vessel, sealing devices are not adequate to control the large blood vessels of the friable mesentery of patients with CD; therefore, we routinely use transfixion sutures. After bowel transection, a side-to-side ileocolic anastomosis is usually fashioned and the bowel is pushed back into the abdominal cavity. The staple lines are routinely over sewn.

We consider the procedure to be "converted" when the abdominal incision is used for any lateral or medial mobilization of the right colon or terminal ileum. Patients receive a single dose of prophylactic antibiotics and are routinely enrolled in an enhanced recovery pathway after surgery.

DEFINITIONS

Steroid use was defined as corticosteroids administered within 1 month prior to surgery, while immunosuppressive use was defined as azathioprine or 6-mercaptopurine used within 2 weeks prior to surgery. Anti-Tumor Necrosis Factor (TNF) monoclonal antibody use was defined as the last infusion of infliximab 4 weeks prior to surgery. Active smoking status was defined as smoking within 4 weeks before surgery, and weight loss was defined as more than 5 kg in the previous 6 months. Duration of the operation was defined as time from skin incision to wound closure.

Mortality was defined as death occurring in the hospital or within 30 days from discharge, while postoperative morbidity was defined as complications occurring in the hospital or within 30 days after surgery.

STATISTICAL ANALYSIS

Categorical variables are presented as frequency or percentage and were compared with the use of the chi-square test or Fisher's exact test, as appropriate. Continuous variables are presented as mean (±standard deviation) or median (range) and were compared with the use of Student's *t*-test. The Mann–Whitney *U* test was used for continuous, not normally distributed outcomes.

To test the presence of potential confounding factors, we analyzed the impact of the history of two or more previous multiple laparotomies (MPL vs NPS) on postoperative morbidity in multivariable logistic regression model, considering also age, sex, ASA grade, BMI, conversion, and operating time.

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS version 16.0; SPSS, Chicago, IL, USA). All reported *p*-values were two-tailed, and *p*-values of less than 0.05 were considered to indicate statistical significance.

ETHICS

The study is conducted in accordance with the principles of the Declaration of Helsinki and "good clinical practice" guidelines. Informed consent has been obtained from the patients.

RESULTS

PATIENT CHARACTERISTICS

In total, 35 patients with history of two or more previous abdominal surgeries underwent laparoscopic ileocolic resection in the study period. Six patients were excluded because one of the two previous surgeries was represented by cesarean section in two cases, laparoscopic appendectomy in two cases, laparoscopic cholecystectomy in one case, and diagnostic laparoscopy in one case.

In total, 29 patients were finally included in the group A—MPL: the number of laparotomies these patients previously underwent was 2 in 19 cases (65.5%), 3 in 9 (31%), and 4 in 1 (3.5%) as detailed in Table 1.

In total, 90 patients with no history of any previous abdominal surgery underwent laparoscopic ileocecal resection for CD in the same study period, representing Group B—NPS.

Baseline patient characteristics are detailed in Table 2. We do not routinely perform ureteric stenting in redo surgery for CD: this was only planned in one patient in the MPL group after review of the imaging at the inflammatory bowel disease multidisciplinary meeting.

TABLE 1

Details of previous surgical procedures in patients with previous multiple laparotomies (group A—MPL).

Patient	Detail of previous surgical procedures
1	Appendectomy via midline for peritonitis, open ileocecal resection, open cholecystectomy via upper midline incision
2	Open small bowel resection, open ileocecal resection, open redo ileocolic resection
3	Open ileocecal resection, open redo ileocolic resection
4	Open ileocecal resection, open redo ileocolic resection
5	Laparotomy and ileostomy for bowel obstruction, open ileocecal resection
6	Open small bowel resection, laparotomy for anastomotic leak and ileostomy, laparotomy for re-resection and anastomosis
7	Open ileocecal resection, open redo ileocolic resection
8	Open ileocecal resection, open redo ileocolic resection, open limited anterior resection
9	Open ileocecal resection, open redo ileocolic resection
10	Open ileocecal resection, open redo ileocolic resection
11	Open ileocecal resection, open redo ileocolic resection
12	Open ileocecal resection, open incisional hernia repair, salpingo-oophorectomy via lower midline incision
13	Open ileocecal resection, open redo ileocolic resection, open redo ileocolic resection, open small bowel resection
14	Open ileocecal resection, open cholecystectomy via upper midline incision
15	Open ileocecal resection, open redo ileocolic resection and stricturoplasty
16	Open small bowel resection, open ileocecal resection
17	Open ileocecal resection, laparotomy and ileostomy for anastomotic leak, laparotomy and re-anastomosis
18	Open ileocecal resection, open hysterectomy via lower midline incision
19	Open ileocecal resection, open redo ileocolic resection
20	Laparotomy and ileostomy for perforation, laparotomy and re-anastomosis
21	Open ileocecal resection, open small bowel resection
22	Open ileocecal resection, open redo ileocolic resection
23	Open ileocecal resection, open redo ileocolic resection
24	Open ileocecal resection, open redo ileocolic resection, open incisional hernia repair
25	Open ileocecal resection, open redo ileocolic resection, open incisional hernia repair
26	Open ileocecal resection, open redo ileocolic resection
27	Open ileocecal resection, open redo ileocolic resection, laparotomy for washout of hematoma
28	Open small bowel resection, open incisional hernia repair
29	Open ileocecal resection, laparotomy for adhesional small bowel obstruction

TABLE 2

Patient characteristics.

	Group A—MPL ($n=29$)	Group B—NPS ($n=90$)	p-value
Age (years)	46.66 ± 15.35	37.62 ± 15.48	0.0071*
Sex (M:F)	11:18	36:54	0.84
BMI	25.5 ± 4.8	24.75 ± 5.53	0.44
ASA			
I	4	16	0.61
II	18	61	0.57
III	7	13	0.22
Conversion to open	1 (3.44%)	4 (4.44%)	0.81
Ileostomy	3 (10.34%)	14 (15.55%)	0.48
Operating time (min)	160.3 ± 41.74	133.4 ± 48.24	0.01
Total ports	3.92 ± 0.62	3.94 ± 0.65	0.89
Blood loss (mL)	61.22 ± 59.17	44.77 ± 62.3	0.26

MPL: multiple previous laparotomies; NPS: no previous abdominal surgery; M: male; F: female; BMI: body mass index; ASA: American Society of Anesthesiologists.

*$p<0.05$.

CONVERSIONS TO OPEN SURGERY

There was one conversion to open surgery (3.44%) in the MPL group and four (4.44%) in the NPS group ($p=0.81$). Reason for conversion in MPL was adhesions and suspected bowel injury, while the three conversions in the NPS group were justified by suspected bowel injury in one case and need to extend the extraction site to complete colonic mobilization in other two cases.

MORBIDITY AND MORTALITY

No mortality was recorded. The 30-day morbidity is detailed in Table 3.

TABLE 3
Postoperative outcomes.

	Group A—MPL ($n=29$)	Group B—NPS ($n=90$)	p-value
LOS (days)	6 (2–49)	5.5 (2–22)	0.17
Readmissions	5 (17.24%)	11 (12.22%)	0.49
Reoperations	1 (3.44%)	5 (5.55%)	0.65
30-day morbidity	7 (24.13%)	23 (25.55%)	0.87
Anastomotic leak	1 (3.44%)	1 (1.11%)	0.39
Wound infection	5 (17.24%)	7 (7.77%)	0.14
Ileus	1 (3.44%)	6 (6.66%)	0.52
Intra-abdominal collection	3 (10.34%)	2 (2.22%)	0.64
SBO	0 (0%)	2 (2.22%)	
Bleeding	1 (3.44%)	3 (3.33%)	0.97

MPL: multiple previous laparotomies; NPS: no previous abdominal surgery; LOS: length of hospital stay; SBO: small bowel obstruction.

TABLE 4
Reasons for readmission within 30 days from hospital discharge.

Group A—MPL: five patients
Two for wound infection Two for abdominal pain One for high-output ileostomy
Group B—NPS: eleven patients
Two for wound infection Two for high-output ileostomy One for wound dehiscence One for rectal bleeding One for abdominal pain One for ileus treated conservatively One for small bowel obstruction requiring laparotomy One for nausea and vomiting One for intra-abdominal collection treated with antibiotics

MPL: multiple previous laparotomies; NPS: no previous abdominal surgery.

The 30-day morbidity was 24.1% and 25.5% in group MPL and NPS, respectively ($p=0.87$). No differences were found in anastomotic leak, wound infection, and postoperative ileus between the two groups. One patient in MPL and three patients in NPS required postoperative blood transfusions.

In total, 11 complications were recorded in 7 patients in group MPL: 4, grade 1; 3, grade 2; and 4, grade 3 according to Dindo–Clavien classification. In total, 25 complications were recorded in NPS group: 9, grade 1; 10, grade 2; and 5, grade 3.

READMISSIONS AND REOPERATIONS

Within 30 days from hospital discharge five patients (17.24%) were readmitted in group MPL and 11 (12.22%) in group NPS, with no difference between the two groups. Reasons for readmission are detailed in Table 4.

Reoperations did not differ significantly between the two groups. One patient (3.44%) was reoperated in MPL and indication for surgery was anastomotic leak requiring laparotomy and ileostomy formation. Five patients (5.55%) were reoperated in NPS group, and indication was small bowel obstruction in two cases, bleeding in two cases, and anastomotic leak in one case.

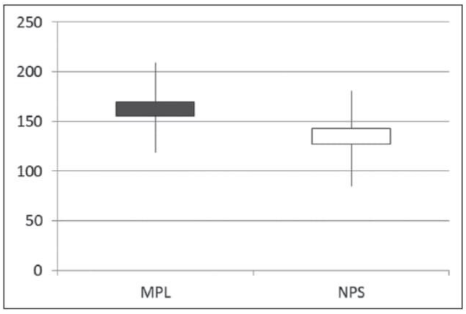


Fig. 1. Mean operating time (min).
MPL: multiple previous laparotomies. NPS: no previous abdominal surgery.

OPERATING TIME AND LOS

Operating time was 160.3 ± 41.74 min in MPL group and 133.4 ± 48.24 min in NPS (Fig. 1). As expected, operating time was slightly longer in the MPL group where adhesiolysis was often needed; however, this difference did not reach statistical significance ($p=0.01$).

Patients in the MPL group spent on average half a day longer in hospital compared to the NPS group (6 and 5.5 days, respectively, $p=0.17$).

DISCUSSION

This study demonstrates that laparoscopic surgery is feasible even in the hostile abdomens of patients with recurrent CD and previous multiple laparotomies. Despite the benefits of laparoscopic surgery (12), a considerable number of CD patients may be a formidable challenge even for the most-experienced laparoscopic surgeon (13).

In addition, the surgeon has to be prepared to deal with unexpected findings that may require additional surgery. These include proximal strictures, fistulas, abscesses, or phlegmons, which can be identified in about 20% of patients (14). This is one of the reasons why these patients benefit particularly from MDT discussion, where not only the indication for surgery is discussed but also the surgical strategy, with careful review of the imaging to plan the surgical approach and the need for adjuncts such as ureteric stents.

Relatively high rates of mortality and septic complications have been reported in patients who undergo resections for CD, with a rate of intra-abdominal sepsis and anastomotic leak of 14% and 17%, respectively (10)

These challenges explain the concerns on feasibility and safety of the laparoscopic approach in redo ileocolic resection for CD; nevertheless, growing evidence is demonstrating a trend toward inclusion of difficult and complex laparoscopic colorectal cases in highly specialized units without compromising results (15, 16).

We routinely offer elective minimally invasive surgery to patients with recurrent ileocolic CD who failed medical therapy; however, this study pushes the boundaries of laparoscopic surgery in a highly selected group of patients with two or more previous laparotomies, in whom complex and technically challenging surgery is expected.

We found a conversion rate of 3.4%, in patients with two or more previous multiple laparotomies, which is significantly less compared to rates of 6.7%, 25%, and 32% of previously published series, where moderate to severe adhesions was the primary indication of conversion to open surgery (6, 17, 18). A standardized approach to adhesiolysis, with the first trocar inserted away from the previous midline scar, the use of a 5-mm camera that can easily be moved in different ports, and careful cold sharp dissection, may explain these results in our unit.

Not surprisingly, we found that redo ileocolic resection for CD in patients with previous multiple abdominal surgeries requires 30 min longer than patients who undergo surgery for the first time. However, it is important to note that this does not reflect in increased rate of complications, which was indeed not different in our study populations.

Our study found a slightly longer postoperative hospital stay in patients who underwent redo surgery. Despite being equally enrolled in an enhanced recovery program, patients with multiple previous abdominal surgeries spent an average of 6 days in hospital compared to 5.5 days of the primary resection group: this difference did not reach statistical significance, and a trend toward older patients with more comorbidities was noted in the redo surgery group.

As outlined in the review of previous studies, there is ample data to support the safety and feasibility of laparoscopic surgery in redo ileocolic resections for CD; however, our study has some limitations. First of all, as the group of patients with two or more multiple laparotomies is a highly selected one, we only enrolled 29 cases in our main intervention group and larger numbers are needed to provide more robust evidence. Nevertheless, no statistical differences were found in baseline patient characteristics between the two study groups. Moreover, the aim of our study was to assess the feasibility of the laparoscopic approach in the extreme setting of ileocolic resection in patients where severe adhesions are common, and technically challenging surgery is expected. Our study, therefore, wants to add new and different evidence to the already available literature on laparoscopic surgery for redo ileocolic resection, and this is manifested by the exclusion of minor laparoscopic procedures from the count of the previous surgeries.

Secondly, our patients have been recruited within a study period of 11 years, and concerns about cases being performed at different stages of the learning curve might be raised, particularly with relation to conversion to open surgery. A cumulative conversion rate of 3.87% (5 cases out of 119) was found in our study, and it is important to note that three of the five conversions happened in the last 3 years of the study period.

Finally, our study did not include an open surgery group, which would have allowed a comparison between the results of laparoscopic surgery and the most commonly alternative approach for redo ileocolic resection for CD. However, open surgery is now rarely offered in our minimally invasive unit in the elective setting, and due to widespread adoption of laparoscopic surgery, we expect that the only way of addressing this question is represented by a multicentre randomized controlled trial, which we are currently designing.

CONCLUSION

Laparoscopic redo ileocolic resection for CD is feasible and safe in specialized laparoscopic Units even in patients with previous multiple laparotomies, at the expense of longer operating time. Randomized controlled trials are needed to produce more robust evidence and compare with open surgery.

DECLARATION OF CONFLICTING INTERESTS

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

FUNDING

The author(s) received no financial support for the research, authorship, and/or publication of this article.

REFERENCES

1. Shaffer VO, Wexner SD: Surgical management of Crohn's disease. Langenbecks Arch Surg 2013;398:13–27.
2. Dasari BV, McKay D, Gardiner K: Laparoscopic versus open surgery for small bowel Crohn's disease. Cochrane Database Syst Rev 2011;19:CD006956.
3. Bernell O, Lapidus A, Hellers G: Risk factors for surgery and recurrence in 907 patients with primary ileocaecal Crohn's disease. Br J Surg 2000;87:1697–1701.
4. Spinelli A, Sacchi M, Bazzi P et al: Laparoscopic surgery for recurrent Crohn's disease. Gastroenterol Res Pract 2012;2012:381017.

5. Gordon PH, Nivatvongs S: *Crohn's Disease*. New York: Informa Healthcare, 2007, pp. 820–907.
6. Holubar SD, Dozois EJ, Privitera A et al: Laparoscopic surgery for recurrent ileocolic Crohn's disease. Inflamm Bowel Dis 2010;16:1382–1386.
7. Tan JJ, Tjandra JJ: Laparoscopic surgery for Crohn's disease: A meta-analysis. Dis Colon Rectum 2007;50:576–585.
8. Lesperance K, Martin MJ, Lehmann R et al: National trends and outcomes for the surgical therapy of ileocolonic Crohn's disease: A population-based analysis of laparoscopic vs. open approaches. J Gastrointest Surg 2009;13:1251–1259.
9. Marcello PW: Laparoscopy for inflammatory bowel disease: Pushing the envelope. Clin Colon Rectal Surg 2006;19:26–32.
10. Yamamoto T, Allan RN, Keighley MR: Risk factors for intra-abdominal sepsis after surgery in Crohn's disease. Dis Colon Rectum 2000;43:1141–1145.
11. Dindo D, Demartines N, Clavien PA: Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205–213.
12. Dunker MS, Stiggelbout AM, van Hogezand RA et al: Cosmesis and body image after laparoscopic-assisted and open ileocolic resection for Crohn's disease. Surg Endosc 1998;12:1334–1340.
13. Celentano V, Finch D, Forster L et al: Safety of supervised trainee-performed laparoscopic surgery for inflammatory bowel disease. Int J Colorectal Dis 2015;30:639–644.
14. Duepree HJ, Senagore AJ, Delaney CP et al: Advantages of laparoscopic resection for ileocecal Crohn's disease. Dis Colon Rectum 2002;45:605–610.
15. Layfield D, Luvisetto F, Celentano V: Fistulating Crohn's terminal ileitis involving sigmoid colon, left salpinx and urinary bladder: Laparoscopic approach—A video vignette. Colorectal Dis 2017;19:783–784.
16. Marush F, Gastinger I, Schneider C et al: Importance of conversion for results obtained with laparoscopic colorectal surgery. Dis Colon Rectum 2001;44:207–214.
17. Chaudhary B, Glancy D, Dixon AR: Laparoscopic surgery for recurrent ileocolic Crohn's disease is as safe and effective as primary resection. Colorectal Dis 2011;13:1413–1416.
18. Pinto RA, Shawki S, Narita K et al: Laparoscopy for recurrent Crohn's disease: How do the results compare with the results for primary Crohn's disease? Colorectal Dis 2011;13:302–307.

Received: September 28, 2017
Accepted: February 26, 2018

Publication n. 5

Celentano, V. (2015) Need for simulation in laparoscopic colorectal surgery training. *World J Gastrointest Surg*. (2015) 27; 7(9):185-9

World Journal of
Gastrointestinal Surgery

Submit a Manuscript: http://www.wjgnet.com/esps/
Help Desk: http://www.wjgnet.com/esps/helpdesk.aspx
DOI: 10.4240/wjgs.v7.i9.185

World J Gastrointest Surg 2015 September 27; 7(9): 185-189
ISSN 1948-9366 (online)

MINIREVIEWS

Need for simulation in laparoscopic colorectal surgery training

Valerio Celentano

Valerio Celentano, Colorectal Unit, Federico Ⅱ University, 80131 Naples, Italy

Author contributions: Celentano V solely contributed to this manuscript.

Conflict-of-interest statement: As a corresponding author I declare that there is no conflict of interest.

Correspondence to: Dr. Valerio Celentano, Colorectal Unit, Federico Ⅱ University, Via Pansini, 5, 80131 Naples, Italy. valeriocelentano@yahoo.it
Telephone: +39-33-95023785

Received: May 9, 2015
Peer-review started: May 11, 2015
First decision: June 2, 2015
Revised: June 30, 2015
Accepted: July 8, 2015
Article in press: July 8, 2015
Published online: September 27, 2015

Abstract

The dissemination of laparoscopic colorectal surgery (LCS) has been slow despite increasing evidence for the clinical benefits, with a prolonged learning curve being one of the main restrictions for a prompt uptake. Performing advanced laparoscopic procedures requires dedicated surgical skills and new simulation methods designed precisely for LCS have been established: These include virtual reality simulators, box trainers, animal and human tissue and synthetic materials. Studies have even demonstrated an improvement in trainees' laparoscopic skills in the actual operating room and a staged approach to surgical simulation with a combination of various training methods should be mandatory in every colorectal training program. The learning curve for LCS could be reduced through practice and skills development in a riskfree setting.

Key words: Surgical simulation; Laparoscopic surgery; Surgical training; Colorectal surgery

Core tip: Performing advanced laparoscopic procedures requires dedicated surgical skills and new simulation methods tailored precisely for laparoscopic colorectal surgery (LCS) have been established. This review focuses on a very actual topic in gastrointestinal surgery: The learning curve in minimally invasive surgery and the need for mechanisms to shorten the time needed for a trainee surgeon to safely move towards independent practice. This review article critically analyses the current role of simulation for LCS training.

Celentano V. Need for simulation in laparoscopic colorectal surgery training. *World J Gastrointest Surg* 2015; 7(9): 185-189 Available from: URL: http://www.wjgnet.com/1948-9366/full/v7/i9/185.htm DOI: http://dx.doi.org/10.4254/wjgs.v7.i9.185

INTRODUCTION

Laparoscopic colorectal surgery (LCS) has been increasingly applied because of its many advantages over conventional surgery, including reduced postoperative pain, earlier recovery of bowel function and shorter hospital stay[1].

Despite the evidence for the clinical benefits of LCS and its oncologic safety[2,3], the dissemination of this technique has been hesitant, one of the main constraints for a swift uptake being an extended learning curve[4].

The high level of technical complexity associated with laparoscopic colectomies was held partially responsible for its relatively low adoption rate when compared with other laparoscopic operations[5,6] and learning curves have been estimated as being between 30 and 60 cases[7,8] with the need to acquire specific skills dissimilar to those used during conventional surgery[9].

LCS is a technically challenging procedure, frequently being self-taught by senior surgeons[10], despite there is available evidence that the absence of appropriate training may lead to patient safety compromise[11].

Nowadays, trainee surgeons are required to gather more technical skills in less time[12]: Research has demonstrated a deficiency of successful performance of enough critical laparoscopic colorectal cases by trainees[13,14].

The proportion of operations undertaken by surgical trainees has reduced in the past decade[15] as they spend less time in theatre and more time covering nights and acute admissions[16,17].

This gap between expected level and actual practice[18] has promoted the use of advanced training in laparoscopic colorectal surgery, with the evident need to improve the training opportunities available to trainees out-of-hours. Aim of this review is to summarize the different simulation strategies currently available for LCS training and the evidence demonstrating their advantages for colorectal trainees.

NEW CHALLENGE FOR SURGICAL TRAINING

Surgical training has traditionally been one of apprenticeship, based on a Halsted's "see one, do one, teach one" classic scheme[19] where the surgical trainee learns to perform surgery under the supervision of an experienced surgeon.

Performing laparoscopic procedures requires special surgical skills to overcome the technical difficulties that it presents (Table 1), which include two-dimensional vision with loss of depth perception, less range of motion of the instruments when compared with open surgery, impaired tactile sensation, and the disparity between visual and proprioceptive feedback known as the fulcrum effect[21,22]. Laparoscopic surgery is difficult to learn by observation and practice alone[23] and competency requires dedicated training and mentoring[24].

Moreover, augmented rates of adverse clinical outcomes at the beginning of the learning curve introduce ethical questions and emphasize the demand for mechanisms to decrease complications and unnecessary conversions to open surgery during the early stage of independent practice. As it is no longer accepted that surgeons acquire experience at the expense of patient safety, patients should not be exposed to the opportunity of harm when other training approaches are available for skill acquisition.

Table 1 Distinctive features and challenges of laparoscopic surgery[20]

Features	Challenges
Two dimensional vision	Reduced perception of depth
A disturbed eye-hand-target axis	Decreases ergonomy and dexterity
Long and inflexible instruments	Natural hand tremor magnified
Rigid instruments with five degrees of freedom	Decreased dexterity and range of motion
Fixed abdominal entry points	Limited freedom of motion and movement of the instrument: The fulcrum effect
Camera instability	Increased fatigue
Limited tactile feedback	Decreases dexterity

It has also been demonstrated that the surgical theatre can be a suboptimal place for beginner learning as high stress leads to deleterious effects on performance[25] and surgical training in the operating room implicates additional cost, estimated in approximately United States $47979 per year per trainee[26].

Concerns regarding cost, time, schedule restriction and safety have arisen and this forced surgeons to innovate and develop new methods of surgical training[27,28] and it became obvious that the learning curve must be abbreviated by learning outside of the surgical theatre[29].

Committed practice on simulators corresponds with improved operative times and efficiency of movement for minimally invasive cholecystectomy. These results indicate that the learning curve for LCS may be reduced with this approach[30]. However, colonic and rectal resections performed laparoscopically are retained to be more difficult than a cholecystectomy as they involve added challenges like the need to operate within multiple quadrants in the abdominal cavity, the dissection of inflamed or obliterated tissue planes, and the safe mobilization of the bowel from confined spaces. LCS training is obviously less adapt to simple box trainers because of the necessity to work in multiple quadrants, transect and extract often large bulky specimens, and perform bowel anastomosis: Advanced surgery needs advanced simulation training.

Laparoscopic training not only has changed the traditional perspective challenging the Haldsted's one century old apprenticeship model[31], but has also induced a prompt development of simulation techniques given the versatility of the video environment and the capability to monitor the motions of the trainees. Adequate training clearly is the desirable way to prevent and diminish potential laparoscopic surgical errors[32].

SIMULATION PRACTICE IN LCS

New simulation methods designed peculiarly for LCS have been established (Table 2). These embrace a combination of virtual reality simulators and box trainers, animal and human tissue, and synthetic materials[33-36].

Traditionally, animal and human cadaver training models have been utilized to improve spatial perception

Table 2 Characteristics of the different types of simulators

Type of simulator	Main features
Box trainers	Low-cost, portable, can be used repeatedly by multiple users. Used to teach basic laparoscopic skills: hand-eye coordination, cutting, suturing, bimanual dexterity. Provide sensory feedback Requires direct observation and supervision by a trainer
Virtual reality simulators	Record several procedure metrics providing feedback to trainees. Recording of training performance for objective evidence of skill performance. Minor degree of sensory feedback and higher initial are the main disadvantages
Hybrid models	Reduced costs compared to cadaveric models. Questionable value of a training model with an alternative structure
Animal and human cadaveric models	Best anatomic and clinical-like model. Avaibility is limited and their use is expensive. Require operative facilities and a funeral service

of surgical anatomy[37,38]: This method of simulation is outstanding to demonstrate dissection, tissue handling and complex surgical techniques, but unfortunately, both these models require very specialized training environments, are very expensive with limited availability, and each trainee probably only gets to perform part of the procedure once.

Box-simulators use laparoscopic instruments set within a physical box. They provide tactile feedback and are relatively inexpensive, however require ongoing maintenance and materials, and require feedback from an observing trainer for maximum efficacy. Lack of availability of trainers and dedicated time for feedback may therefore limit this system.

Virtual reality simulators enable trainees to interface with a computer-generated environment that reproduces individual skills or entire procedures. Modern virtual reality simulators utilize increasingly advanced hardware and software for complex and realistic simulation: They have an higher initial cost but are valuable not only as a training device but also as a tool to assess surgical skills. In fact they provide pre-task tutorials and feedbacks at the completion of the procedure on a range of outputs such as time taken, efficiency of motion and knot integrity. Virtual reality simulator systems are convenient for the trainer as performance of the trainee can be monitored easily and remotely, meaning this system can be well utilized out-of-hours.

FUTURE PERSPECTIVES

Several studies have demonstrated that training in laparoscopic techniques in a simulated setting, including on virtual-reality simulators, has enhanced the capabilities of the surgical trainees during and beyond the course of their training[39,40]. Some studies have even shown an amelioration in trainees' laparoscopic skills in the actual surgical theatre[41,42] and it is now largely accepted that laparoscopic simulation training should be mandatory[43] to facilitate trainees acquire basic laparoscopic skills, and a growing consensus by regulation training bodies is desirable.

Proficiency-based simulator curricula have proven effective in improving the performance of trainees. An assessment of baseline skills level on laparoscopic colectomy for trainee surgeons may be used to fashion a tailored program dedicated to improve specific competences and to meet the needs of novice surgeons according to their specific pre-training skills.

Skills of different complexity can be achieved using a phased approach and a mixture of distinct simulation training techniques. Basic surgical competences such instrument handling and suturing should be developed in box trainers and virtual reality simulators, while advanced key steps in complex procedure mastered using torso-shapped mannequin with synthetic materials. Finally, as LCS requires cooperation among the surgeon, the assistants and the operating team personnel, advanced laparoscopy team training should be done in animal/cadaver/hybrid labs with a minimal number of required animals or cadavers.

CONCLUSION

Training in LCS requires specific psychomotor skills that trainee surgeons are required to gather in less time. Simulation may offer a safe, reproducible environment for development of technical skills and procedural knowledge. The learning curve for LCS could be reduced through practice and skills development in a risk-free setting and a staged approach to simulation training should be mandatory in every colorectal training program.

REFERENCES

1 **Guillou PJ**, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, Heath RM, Brown JM. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. *Lancet* 2005; **365**: 1718-1726 [PMID: 15894098 DOI: 10.1016/s0140-6736(05)66545-2]

2 **Faiz O**, Warusavitarne J, Bottle A, Tekkis PP, Darzi AW, Kennedy RH. Laparoscopically assisted vs. open elective colonic and rectal resection: a comparison of outcomes in English National Health Service Trusts between 1996 and 2006. *Dis Colon Rectum* 2009; **52**: 1695-1704 [PMID: 19966600 DOI: 10.1007/dcr.0b013e3181b55254]

3 **Hewett PJ**, Allardyce RA, Bagshaw PF, Frampton CM, Frizelle FA, Rieger NA, Smith JS, Solomon MJ, Stephens JH, Stevenson AR. Short-term outcomes of the Australasian randomized clinical study comparing laparoscopic and conventional open surgical treatments for colon cancer: the ALCCaS trial. *Ann Surg* 2008; **248**: 728-738 [PMID: 18948799 DOI: 10.1097/sla.0b013e31818b7595]

4 **Miskovic D**, Ni M, Wyles SM, Tekkis P, Hanna GB. Learning curve and case selection in laparoscopic colorectal surgery: systematic review and international multicenter analysis of 4852 cases. *Dis Colon Rectum* 2012; **55**: 1300-1310 [PMID: 23135590 DOI: 10.1097/dcr.0b013e31826ab4dd]

5 **Bardakcioglu O**, Khan A, Aldridge C, Chen J. Growth of laparoscopic colectomy in the United States: analysis of regional and socioeconomic factors over time. *Ann Surg* 2013; **258**: 270-274 [PMID: 23598378 DOI: 10.1097/sla.0b013e31828faa66]

6 **Kemp JA**, Finlayson SR. Nationwide trends in laparoscopic colectomy from 2000 to 2004. *Surg Endosc* 2008; **22**: 1181-1187 [PMID: 18246394 DOI: 10.1007/s00464-007-9732-8]

7 **Tekkis PP**, Senagore AJ, Delaney CP, Fazio VW. Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. *Ann Surg* 2005; **242**: 83-91 [PMID: 15973105 DOI: 10.1097/01.sla.0000167857.14690.68]

8 **Choi DH**, Jeong WK, Lim SW, Chung TS, Park JI, Lim SB, Choi HS, Nam BH, Chang HJ, Jeong SY. Learning curves for laparoscopic sigmoidectomy used to manage curable sigmoid colon cancer: single-institute, three-surgeon experience. *Surg Endosc* 2009; **23**: 622-628 [PMID: 18270771 DOI: 10.1007/s00464-008-9753-y]

9 **Kim J**, Edwards E, Bowne W, Castro A, Moon V, Gadangi P, Ferzli G. Medial-to-lateral laparoscopic colon resection: a view beyond the learning curve. *Surg Endosc* 2007; **21**: 1503-1507 [PMID: 17641928 DOI: 10.1007/s00464-006-9085-8]

10 **Miskovic D**, Wyles SM, Ni M, Darzi AW, Hanna GB. Systematic review on mentoring and simulation in laparoscopic colorectal surgery. *Ann Surg* 2010; **252**: 943-951 [PMID: 21107103 DOI: 10.1097/sla.0b013e3181f662e5]

11 A prospective analysis of 1518 laparoscopic cholecystectomies. The Southern Surgeons Club. *N Engl J Med* 1991; **324**: 1073-1078 [PMID: 1826143 DOI: 10.1056/nejm199104183241601]

12 **Stein S**, Stulberg J, Champagne B. Learning laparoscopic colectomy during colorectal residency: what does it take and how are we doing? *Surg Endosc* 2012; **26**: 488-492 [PMID: 21938581 DOI: 10.1007/s00464-011-1906-8]

13 **Bass BL**. Matching training to practice: the next step. *Ann Surg* 2006; **243**: 436-438 [PMID: 16552192 DOI: 10.1097/01.sla.0000205222.95167.a4]

14 **Pugh CM**, Darosa DA, Bell RH. Residents' self-reported learning needs for intraoperative knowledge: are we missing the bar? *Am J Surg* 2010; **199**: 562-565 [PMID: 20359575 DOI: 10.1016/j.amjsurg.2009.11.003]

15 **Blencowe NS**, Parsons BA, Hollowood AD. Effects of changing work patterns on general surgical training over the last decade. *Postgrad Med J* 2011; **87**: 795-799 [PMID: 21984742 DOI: 10.1136/postgradmedj-2011-130297]

16 **Varley I**, Keir J, Fagg P. Changes in caseload and the potential impact on surgical training: a retrospective review of one hospital's experience. *BMC Med Educ* 2006; **6**: 6 [PMID: 16420692 DOI: 10.1186/1472-6920-6-6]

17 **Taylor IA**, Alexander F. Preface to the ISCP report. ISCP Evaluation Task Group, 2006. Available from: URL: http://www.mee.nhs.uk/pdf/FinalReportISCP - MichaelEraut.pdf

18 **Bell RH**, Biester TW, Tabuenca A, Rhodes RS, Cofer JB, Britt LD, Lewis FR. Operative experience of residents in US general surgery programs: a gap between expectation and experience. *Ann Surg* 2009; **249**: 719-724 [PMID: 19387334 DOI: 10.1097/sla.0b013e3181a38e59]

19 **Kerr B**, O'Leary JP. The training of the surgeon: Dr. Halsted's greatest legacy. *Am Surg* 1999; **65**: 1101-1102 [PMID: 10551765]

20 **Heemskerk J**, Zandbergen R, Maessen JG, Greve JW, Bouvy ND. Advantages of advanced laparoscopic systems. *Surg Endosc* 2006; **20**: 730-733 [PMID: 16528462 DOI: 10.1007/s00464-005-0456-3]

21 **Scott DJ**, Young WN, Tesfay ST, Frawley WH, Rege RV, Jones DB. Laparoscopic skills training. *Am J Surg* 2001; **182**: 137-142 [PMID: 11574084 DOI: 10.1016/s0002-9610(01)00669-9]

22 **Smith CD**, Farrell TM, McNatt SS, Metreveli RE. Assessing laparoscopic manipulative skills. *Am J Surg* 2001; **181**: 547-550 [PMID: 11513783]

23 **Dutta S**, Gaba D, Krummel TM. To simulate or not to simulate: what is the question? *Ann Surg* 2006; **243**: 301-303 [PMID: 16495691 DOI: 10.1097/01.sla.0000200853.69108.6d]

24 **Celentano V**, Finch D, Forster L, Robinson JM, Griffith JP. Safety of supervised trainee-performed laparoscopic surgery for inflammatory bowel disease. *Int J Colorectal Dis* 2015; **30**: 639-644 [PMID: 25669758 DOI: 10.1007/s00384-015-2147-4]

25 **Park J**, MacRae H, Musselman LJ, Rossos P, Hamstra SJ, Wolman S, Reznick RK. Randomized controlled trial of virtual reality simulator training: transfer to live patients. *Am J Surg* 2007; **194**: 205-211 [PMID: 17618805 DOI: 10.1016/j.amjsurg.2006.11.032]

26 **Bridges M**, Diamond DL. The financial impact of teaching surgical residents in the operating room. *Am J Surg* 1999; **177**: 28-32 [PMID: 10037304 DOI: 10.1016/s0002-9610(98)00289-x]

27 **Gurusamy KS**, Aggarwal R, Palanivelu L, Davidson BR. Virtual reality training for surgical trainees in laparoscopic surgery. *Cochrane Database Syst Rev* 2009; **21**: CD006575 [PMID: 19160288 DOI: 10.1002/14651858.cd006575]

28 **Scott DJ**, Bergen PC, Rege RV, Laycock R, Tesfay ST, Valentine RJ, Euhus DM, Jeyarajah DR, Thompson WM, Jones DB. Laparoscopic training on bench models: better and more cost effective than operating room experience? *J Am Coll Surg* 2000; **191**: 272-283 [PMID: 10989902 DOI: 10.1016/s1072-7515(00)00339-2]

29 **Samia H**, Khan S, Lawrence J, Delaney CP. Simulation and its role in training. *Clin Colon Rectal Surg* 2013; **26**: 47-55 [PMID: 24436648 DOI: 10.1055/s-0033-1333661]

30 **Aggarwal R**, Ward J, Balasundaram I, Sains P, Athanasiou T, Darzi A. Proving the effectiveness of virtual reality simulation for training in laparoscopic surgery. *Ann Surg* 2007; **246**: 771-779 [PMID: 17968168 DOI: 10.1097/sla.0b013e3180f61b09]

31 **Halsted WS**. The training of the surgeon. *Bull Johns Hopkins Hosp* 1904; **15**: 267-276

32 **Moore MJ**, Bennett CL. The learning curve for laparoscopic cholecystectomy. The Southern Surgeons Club. *Am J Surg* 1995; **170**: 55-59 [PMID: 7793496 DOI: 10.1016/s0002-9610(99)80252-9]

33 **Bashankaev B**, Baido S, Wexner SD. Review of available methods of simulation training to facilitate surgical education. *Surg Endosc* 2011; **25**: 28-35 [PMID: 20552373 DOI: 10.1007/s00464-010-1123-x]

34 **Roberts KE**, Bell RL, Duffy AJ. Evolution of surgical skills training. *World J Gastroenterol* 2006; **12**: 3219-3224 [PMID: 16718842]

35 **Waseda M**, Inaki N, Mailaender L, Buess GF. An innovative trainer for surgical procedures using animal organs. *Minim Invasive Ther Allied Technol* 2005; **14**: 262-266 [PMID: 16754173 DOI: 10.1080/13645700500273841]

36 **Ramshaw BJ**, Young D, Garcha I, Shuler F, Wilson R, White JG, Duncan T, Mason E. The role of multimedia interactive programs in training for laparoscopic procedures. *Surg Endosc* 2001; **15**: 21-27 [PMID: 11178755 DOI: 10.1007/s004640000319]

37 **Ross HM**, Simmang CL, Fleshman JW, Marcello PW. Adoption of laparoscopic colectomy: results and implications of ASCRS hands-on course participation. *Surg Innov* 2008; **15**: 179-183 [PMID: 18757376 DOI: 10.1177/1553350608322100]

38 **Katz R**, Hoznek A, Antiphon P, Van Velthoven R, Delmas V, Abbou CC. Cadaveric versus porcine models in urological laparoscopic training. *Urol Int* 2003; **71**: 310-315 [PMID: 14512654 DOI: 10.1159/000072684]

39 **Grantcharov TP**, Kristiansen VB, Bendix J, Bardram L, Rosenberg J, Funch-Jensen P. Randomized clinical trial of virtual reality simulation for laparoscopic skills training. *Br J Surg* 2004; **91**: 146-150 [PMID: 14760660 DOI: 10.1002/bjs.4407]

40 **Gallagher AG**, Ritter EM, Champion H, Higgins G, Fried MP, Moses G, Smith CD, Satava RM. Virtual reality simulation for the operating room: proficiency-based training as a paradigm shift in surgical skills training. *Ann Surg* 2005; **241**: 364-372 [PMID: 15650649 DOI: 10.1097/01.sla.0000151982.85062.80]

41 **Hyltander A**, Liljegren E, Rhodin PH, Lönroth H. The transfer of basic skills learned in a laparoscopic simulator to the operating room. *Surg Endosc* 2002; **16**: 1324-1328 [PMID: 11988802]

42 **Seymour NE**, Gallagher AG, Roman SA, O'Brien MK, Bansal VK, Andersen DK, Satava RM. Virtual reality training improves operating room performance: results of a randomized, double-blinded study. *Ann Surg* 2002; **236**: 458-463; discussion 463-464

[PMID: 12368674]
43 **Zimmerman H**, Latifi R, Dehdashti B, Ong E, Jie T, Galvani C, Waer A, Wynne J, Biffar D, Gruessner R. Intensive laparoscopic training course for surgical residents: program description, initial results, and requirements. *Surg Endosc* 2011; **25**: 3636-3641 [PMID: 21643881 DOI: 10.1007/s00464-011-1770-6]

P- Reviewer: Fukunaga Y, Lakatos PL
S- Editor: Ji FF **L- Editor**: A **E- Editor**: Li D

Publication n. 6

Celentano, V., Browning, M., Hitchins, C., Giglio, M.C., Coleman, M.G. (2017). Training value of laparoscopic colorectal videos on the World Wide Web: a pilot study on the educational quality of laparoscopic right hemicolectomy videos. *Surg Endosc*. 2017 Nov;31(11):4496-4504.

Surg Endosc (2017) 31:4496–4504
DOI 10.1007/s00464-017-5504-2

Training value of laparoscopic colorectal videos on the World Wide Web: a pilot study on the educational quality of laparoscopic right hemicolectomy videos

V. Celentano[1] · M. Browning[1] · C. Hitchins[1] · M. C. Giglio[2] · M. G. Coleman[1]

Received: 3 August 2016 / Accepted: 8 March 2017 / Published online: 4 April 2017

Abstract

Introduction Instructive laparoscopy videos with appropriate exposition could be ideal for initial training in laparoscopic surgery, but unfortunately there are no guidelines for annotating these videos or agreed methods to measure the educational content and the safety of the procedure presented. Aim of this study is to systematically search the World Wide Web to determine the availability of laparoscopic colorectal surgery videos and to objectively establish their potential training value.

Methods A search for laparoscopic right hemicolectomy videos was performed on the three most used English language web search engines Google.com, Bing.com, and Yahoo.com; moreover, a survey among 25 local trainees was performed to identify additional websites for inclusion. All laparoscopic right hemicolectomy videos with an English language title were included. Videos of open surgery, single incision laparoscopic surgery, robotic, and hand-assisted surgery were excluded. The safety of the demonstrated procedure was assessed with a validated competency assessment tool specifically designed for laparoscopic colorectal surgery and data on the educational content of the video were extracted.

Results Thirty-one websites were identified and 182 surgical videos were included. One hundred and seventy-three videos (95%) detailed the year of publication; this demonstrated a significant increase in the number of videos published per year from 2009. Characteristics of the patient were rarely presented, only 10 videos (5.4%) reported operating time and only 6 videos (3.2%) reported 30-day morbidity; 34 videos (18.6%) underwent a peer-review process prior to publication. Formal case presentation, the presence of audio narration, the use of diagrams, and snapshots and a step-by-step approach are all characteristics of peer-reviewed videos but no significant difference was found in the safety of the procedure.

Conclusions Laparoscopic videos can be a useful adjunct to operative training. There is a large and increasing amount of material available for free on the internet, but this is currently unregulated.

Keywords Laparoscopic surgery · Colorectal surgery · Surgical training · Distance learning · Surgical videos · Right hemicolectomy

Electronic supplementary material The online version of this article (doi:10.1007/s00464-017-5504-2) contains supplementary material, which is available to authorized users.

✉ V. Celentano
valeriocelentano@yahoo.it

[1] Colorectal Unit, Plymouth Hospitals NHS Trust, Plymouth, UK

[2] Department of Clinical Medicine and Surgery, School of Medicine, Federico II University, Naples, Italy

The traditional apprentice model for surgeons in training requires sufficient opportunities and time to learn surgical skills under the direction and supervision of an experienced trainer [1]. The operating room represents an essential learning environment which cannot be fully replaced, but with duty hour restrictions, heightened concerns for patient safety and increased levels of staff supervision, surgical trainees may have less autonomy and educational time in the operating theatre. With the decrease in opportunities to experience surgery at many teaching hospitals [2, 3], the problem of how to make education more efficient has taken on greater importance.

Laparoscopic surgery has become widespread and it has been increasingly applied in colorectal surgery [4]. However, despite the evidence for the clinical benefits of laparoscopic colorectal surgery and its oncologic safety [5], the dissemination of this technique has been hesitant, due to the technical complexity of the procedure and a prolonged learning curve [6].

Performing advanced laparoscopic procedures requires dedicated surgical skills [7] to overcome specific technical difficulties which include two-dimensional vision with loss of depth perception, less range of motion of the instruments, impaired tactile sensation, and the disparity between visual and proprioceptive feedback known as the fulcrum effect [8]. Such challenges in surgical education require new learning tools to try and overcome the time constraints [9, 10].

Audiovisual presentations are recognized in the medical field as important educational materials; thus, they are used to communicate information effectively to clinicians, patients, and students [11–14].

Fortunately, laparoscopic surgery lends itself to the production of audiovisual educational materials. Current endoscopy systems are in fact equipped with video-recording devices, making it easy to capture high-quality images in a digital format. The video recording of the procedure shows exactly what the surgeon is viewing providing surgical trainees with essential information regarding anatomy and the different steps of the operation.

Instructive laparoscopy videos with appropriate exposition could be ideal for initial training in laparoscopic surgery [15], but unfortunately there are no guidelines for annotating these videos or agreed methods to measure the educational content and the safety of the procedure presented.

Uploading videos and sharing information on open access media broadcasting channels requires minimal technical skills and is now widely used by individuals and organizations, who wish to reach out to the global audience and share information about scientific issues [16, 17].

Recent studies suggest that these sources hold promise as educational tools for scientific disciplines [18], utilizing sophisticated visual didactic materials. Due to these characteristics, many videos of laparoscopic surgery procedures have been uploaded on these channels and many viewers are watching them [19].

The trustworthiness of a large proportion of publicly available files remains questionable as not all videos are authoritative and may not show techniques based on solid evidence. They may contain incorrect or misleading promotional information [20, 21].

Laparoscopic surgical videos could represent an educational resource for colorectal surgery trainees. This study aims to systematically search the World Wide Web to determine the availability of laparoscopic colorectal surgery videos and to objectively establish their potential training value in terms of safety of the procedure demonstrated and the quality of the educational content presented.

Methods

Search strategy

After the development of a review protocol, a broad search for laparoscopic right hemicolectomy videos was independently performed by two authors on the three most used English language internet search engines (Google.com, Bing.com, and Yahoo.com) using the keywords "laparoscopic colorectal video" and "right hemicolectomy video."

The first 100 results of each search were considered and all websites containing surgical videos were assessed. Sponsored links, advertisements, and surgeons' private practice websites were not considered. Moreover, in order to include as many websites as possible, reflecting the actual use of internet by trainees, a survey among 25 local trainees was performed to identify further websites for inclusion.

All retrieved websites were systematically searched for laparoscopic right hemicolectomy videos using the following search terms: right hemicolectomy, right colectomy, laparoscopic colectomy, minimally invasive colectomy, keyhole colectomy, and laparoscopic colorectal surgery. When a browse function of the available videos was present on the website, right hemicolectomy videos were retrieved manually. The last search was run on 13, November 2015.

Eligibility criteria and video selection

All videos of laparoscopic right hemicolectomy with an English language title were included.

Open surgery, single incision laparoscopic surgery (SILS), robotic, and hand-assisted surgery videos were excluded, as were videos from fee charging websites. Videos only demonstrating the anastomosis or the specimen extraction technique or the use of a new device for a single step of the procedure were excluded as were videos of combined surgical procedures.

Two reviewers independently assessed the videos for eligibility at title level. The inter-reviewer's agreement was explored through the Cohen's Kappa statistic. In case of discrepancies, a third author was consulted and agreement was reached by consensus.

When the same author and institution published the same video on different websites, only the most recent video was evaluated.

Data extraction

Two authors independently retrieved the data from each included video completing an electronic database with the records detailed in Table 1.

Assessment of the safety of the recorded procedure: laparoscopic competency assessment tool (LCAT)

In order to assess the safety of the demonstrated procedure, a validated competency assessment tool specifically designed for laparoscopic colorectal surgery was used [22]. The laparoscopic competency assessment tool (LCAT) is a task-specific marking sheet for the assessment of technical surgical skills in laparoscopic colorectal surgery. It is designed to assess the surgeon's performance by watching a live, live-streamed or recorded operation. The procedure is divided into four different tasks: each task has 4 different items which are scored based on the safety and effectiveness of the procedure. Task Step 1: "Exposure" begins with the first port insertion and ends when the exposure of the operating field is completed and dissection commences. Low scores are assigned in case of forceful and potentially dangerous port insertion as for ineffective grasping of the bowel and mesentery and exposure of the operative field. Task Step 2: "Vascular pedicle" starts with the retraction of the vascular pedicle and ends with the complete dissection of the vein and artery, focusing on the assessment of appropriate level of section of the vascular pedicle and avoiding blind application of clips/stapler. Task Step 3: "Mobilization" starts with the separation of tissue planes after dissecting the vascular pedicle. It ends when the segment of large bowel is fully mobilized and ready to be resected, with the procedure scored against the adequacy of tissue planes maintained and length of mobilized bowel. Task Step 4: "Resection/anastomosis" starts with the preparation

Table 1 Data extracted from the included videos

Video characteristics	Date uploaded Country Total number of views and 30-day views Video length, full length or edited Conference, surgical society or live surgery video Peer review prior to publication
Image quality	High-definition Amount of time video affected by poor quality image
Supplementary educational content	Presence of audio or written commentary Use of diagrams and screenshots Procedure divided in steps Formal case presentation Preoperative imaging
Patient details	Age Sex BMI Indication for surgery Comorbidities, ASA score Previous surgery
Surgical details	Number of steps of the procedure demonstrated according to the LCAT* Position of the patient Position of the surgeon Number and position of the ports Site of specimen extraction Open part of the procedure demonstrated
Outcomes	Total operating time Intraoperative complications Estimated blood loss 30-day morbidity Length of hospital stay Pathologic staging and number of retrieved lymph nodes in case of malignancy

BMI body mass index, *ASA* American Society of Anaesthesiologists classification, *LCAT* laparoscopic competency assessment tool

* Exposure, vascular pedicle, colonic mobilization, anastomosis

of the bowel for dissection (e.g., clearance of mesentery around terminal ileum) and ends with the complete dissection of bowel and the creation of the anastomosis.

In summary, the surgical performance in each operative video recording was assessed by two independent assessors using the competency assessment tool. The overall mean score for each case (2 assessors, 16 items) ranges from 1 to 4, and the pass mark was set at 2.7 as validated in a previous study [23]. This pass mark was the score above which expert assessors rated the operations as 'safe performance,' defined by receiver operating characteristic (ROC) curve analysis.

Statistical analysis

Categorical data are presented as frequency counts and associated percentages; comparisons were made by means of Pearson's χ^2 test. Continuous data are presented as medians and ranges and were compared by using the Wilcoxon rank-sum test. A p value equal to or less than 0.05 was considered to be statistically significant. Statistical analyses were performed using STATA 12 statistical software (STATA Corp, College Station, Texas, USA).

Results

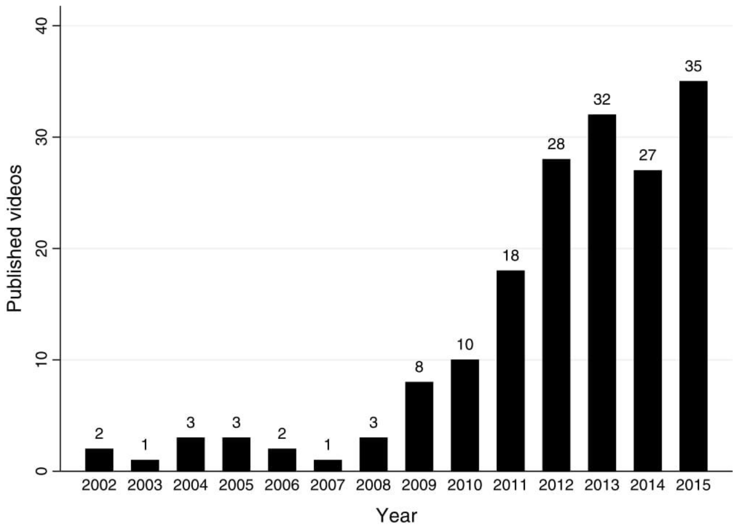
Search results

Thirty-one relevant websites were identified and 222 videos were retrieved, in which 15 duplicates, 11 videos not demonstrating a surgical procedure and 1 video not available for free were excluded. After the exclusion of 3 SILS, 2 robotic, 2 open surgery, 2 hand-assisted surgery, 2 videos only demonstrating the anastomosis, 1 combined surgical procedure, and 1 non-functioning link, 182 surgical videos were finally included. The Kappa statistic showed a high ($K=0.96$) agreement between reviewers on videos' selection.

Video characteristics

Thirty-seven videos (20.3%) were available in high-definition, while 41 (22.5%) demonstrated poor video quality which affected a clear vision for more than 50% of the video length. A vast majority of the videos were edited or truncated, in fact only 14 (7.6%) of the procedures demonstrated were recorded in full length. Six videos (3%) were presented at surgical meetings and 36 (19.7%) were presented by surgical societies, while 15 (8.2%) were recorded during a live-surgery session. Median video length was 9.27 min (range 1.05–155). One hundred and seventy-three videos (95%) detailed the year of publication: this demonstrated a significant increase in the number of videos published per year from 2009 onwards (Fig. 1). A video

Fig. 1 Number of included videos per year



commentary was present in 107 cases (58%), 88.7% of commentaries were in English.

Patient characteristics

The characteristics of the patient were rarely presented. Forty-five (24.7%) videos detailed age which was 62 years (22–91), and 54 (29.6%) detailed sex, which was female in 61%. Only 14 videos (7.6%) reported BMI which was 23.5 (20–38) and only 4 videos (2.1%) detailed the American Society of Anesthesiologists (ASA) score.

Indication for surgery was reported in 103 videos (56.5%): this was cancer in 77.7%, IBD in 9.7%, with a mix of other indications making the remaining 12.6%.

Only 15 videos (8.2%) indicated if the patient had undergone previous abdominal surgery: this was none in 8 cases, 1 in 6 and multiple surgeries in 1.

Characteristics of the surgical procedures demonstrated

Exposure was shown in 41 (22.5%) videos and this was scored as safe in 87.2% of the cases according to the LCAT form.

The approach to the vascular pedicle was the most commonly demonstrated part of the procedure and was shown in 163 videos (89.5%), but this was considered safe in only 66% of the cases.

Colonic mobilization was demonstrated in 145 videos (79.7%) and safe in 69.8%, while the anastomosis was presented in 100 videos (54.9%) and safe in 87.7%.

Patient position on the operating table was shown in 41 (22.5%) of the videos, while surgeon's position only in 31 (17%).

Ports position was demonstrated in 80 (43.9%) of the videos, while specimen extraction was detailed in 100 (54.9%).

Outcome of the procedure

Only 10 videos (5.4%) reported operating time which was 75.5 min (42–300). Surprisingly, only 6 videos (3.2%) reported 30-day morbidity, which was zero in all. None of the videos reported estimated blood loss. Length of hospital stay was reported in 23 videos (12.6%) and was 4.4 days (1–9). When indication for surgery was cancer, as in 80 cases (43.9%), the final histology was reported in 30 (37.5%) and number of retrieved lymph nodes specified in 14 cases (17.5%).

Peer-reviewed vs not peer-reviewed

Thirty-four out of 182 videos (18.6%) underwent a peer-review process prior to publication. Formal case presentation, the presence of audio narration, the use of diagrams and snapshots, demonstration of the anastomosis, and a step-by-step approach are all characteristics of peer-reviewed videos (Table 2). However, 30-day morbidity

Table 2 Comparison of peer-reviewed with not peer-reviewed laparoscopic right hemicolectomy videos

	Peer-reviewed ($n=34$)	Not peer-reviewed ($n=148$)	*P* value
Views per month	11.55 [1.1, 177.5][a]	34.65 [0.2, 979.6][a]	0.252
Video length	9.04 [1.33–37.40][a]	11.94 [1.05–155][a]	0.080
HD	5 (14.7%)	32 (21.6%)	0.366
Audio narration	33 (97%)	74 (50%)	0.001*
Diagrams	21 (61.7%)	38 (25.7%)	0.001*
Case presentation	21 (61.7%)	36 (24.3%)	0.001*
Patient position	22 (64.7%)	19 (12.8%)	0.001*
Surgeon position	19 (55.9%)	12 (8.1%)	0.001*
Ports position	29 (85.3%)	51 (34.4%)	0.001*
Open phase demonstrated	16 (47%)	62 (41.9%)	0.583
Step-by-step approach	29 (85.3%)	71 (48%)	0.001*
Morbidity[††]	2 (5.9%)	4 (2.7%)	0.349
LOS[a] (days)	4 [3–7][a]	4.5 [1–9][a]	0.76
Histology[†]	8 out of 21 (38.1%)	22 out of 59 (37.2%)	0.219

HD high-definition, *LOS* length of hospital stay

[a]Data are expressed as median (range)

**P* value equal or less than 0.05 was considered to be statistically significant

[†]Histology details when indication for surgery was cancer

[††]Number of videos in whom details on 30-day morbidity were presented

and LOS are as rarely reported in peer-reviewed as in non peer-reviewed videos. In display of exposure, vascular dissection, and colonic mobilization are found to be evenly distributed amongst peer-reviewed and non peer-reviewed videos. Peer-reviewed videos did not demonstrate higher LCAT safety scores.

Despite their greater use of narration and educational annotation, peer-reviewed videos do not have increased numbers of views per month; however, videos in which the steps demonstrated are all safe (57.7%), according to the LCAT, are significantly more viewed than videos in which one or more steps are not safe (42.3%), with views per month of 46.1 (0.3–979) and 12.7 (0.2–803), respectively ($P = 0.005$).

The proportion of peer-reviewed videos has significantly decreased over the years; in fact, 17 out of 23 videos published before the year 2010 were peer-reviewed, while only 17 out of 150 videos published after 2010 were peer-reviewed (Fig. 2).

In the same time period, the number of videos which demonstrate parts of the procedure performed "not safely" according to the LCAT score has also increased (Fig. 3).

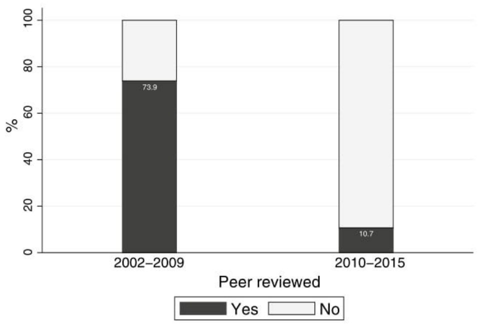


Fig. 2 Rate of peer-reviewed videos in 2002–2009, and 2010–2015

Live surgery videos

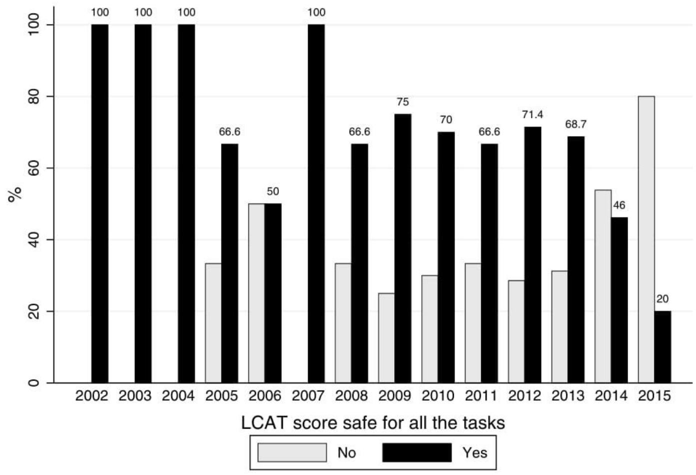
A step-by-step approach to the procedure was more common in live surgery videos as was formal case presentation. Operating ports, patient and surgeons' position were ordinarily demonstrated as was the open part of the procedure.

As with the peer-reviewed videos, the live surgery videos were more likely to show all parts of the surgical procedure than those not live recorded.

Discussion

This is the first study to assess the quality, safety, and educational value of laparoscopic colorectal videos published on the World Wide Web. The relevance of the topic is confirmed by the consistent increase we found in the number of laparoscopic colorectal videos published over the last 7 years. It is concerning that the rate of videos undergoing a formal peer-review process prior to publication has markedly decreased. This suggests that the publication of peer-reviewed videos for formal educational training has remained relatively stable, while the numbers of videos published by individuals have grown rapidly and continue to do so. This has the potential implication of reduced overall quality in terms of educational content presented to surgical trainees, although fortunately we saw no reduction in

Fig. 3 Rate of videos in which all the tasks demonstrated were considered safe according to the LCAT scores



the safety of the procedures being demonstrated from these wider sources.

Our study is the first to acknowledge that there is a large resource available for distance learning in laparoscopic colorectal surgery, but significant variability exists among the videos with most of them lacking information on essential patient details such as age, comorbidities, and BMI, and procedure outcomes such as operating time, length of hospital stay, morbidity, and histology. The lack of information on port placement and surgeons and patient position also reflect how many videos are not suitable for educational purposes.

Peer-reviewed laparoscopic colorectal videos could represent a high-quality tool for distance learning, demonstrating a complex surgical procedure performed safely and effectively with a step-by-step approach, with supplementary material for educational purposes. However, these currently represent less than 20% of the resource available, and this has decreased since 2010.

As with peer-reviewed videos, we found that live-surgery broadcasts were more likely to show positioning and ports placement. They were also more likely to show all the steps of the procedure and these steps were more often performed safely. Live surgery broadcasts are therefore a promising training tool in terms of both safety of the procedure and educational content presented. They may be particularly useful to less experienced trainees who will

value careful narration and description of the systematic approach to the operation.

Courses including live surgical demonstrations are increasingly popular and considered to be useful not only for trainees but also for the independently practicing surgeons as an effective source of continuing medical education [24]. Nevertheless, despite their potential educational benefits, significant concerns about patient safety and clinical integrity remain [25]. Operating surgeons have in fact reported high levels of anxiety when performing live-demonstrations, which increased further when these took place at a foreign institution or in an unfamiliar environment [26, 27].

Performing complex laparoscopic procedures before a live audience creates a unique set of circumstances, which puts additional pressure on the surgeon and could expose the patient to increased risk. Patients should be made fully aware of the implications and potential risks associated with live surgery broadcasts [28] and surgeons should only perform standard procedures in which they are expert. To reduce anxiety and eliminate unfamiliarity with staff and equipment, it is advisable to perform complex surgical procedures only at the surgeon's home institution.

Our study has some limitations. Only websites mentioned in the first 100 results from each search were extracted. We know that the results with the most hits does not always mean the best quality [18]; however, 100 is a large number and therefore likely to be representative of the resources available. We faced the challenge of searching for scientific content on resources not specifically designed for this purpose, shifting from medical databases commonly used for systematic reviews, to websites designed for video sharing. Acknowledging this is as important as it is to note that the search strategy we used is more likely to reproduce how surgical trainees search for video educational material, which is the main focus of our review, as demonstrated by the additional trainees' survey we performed to minimize the risk of missing data.

We also found that those videos that were peer-reviewed or "safe" (according to LCAT) had more views than unreviewed and "not-safe" videos and therefore would be listed higher up in the search results.

The LCAT scoring system has been validated to assess the safety and quality of whole laparoscopic procedures, including video-recorded [22, 23]. A majority of the videos reviewed were edited and did not always include all parts of the procedure. However, in terms of assessing the procedure presented in the video clips available, we feel LCAT is the most useful objective tool available at this time.

As we have shown, there is a huge resource of laparoscopic videos available on the internet. Some sources such as WebSurg have been specifically designed for education; however this is not true of all sources. It is unfair to assume that all the laparoscopic colorectal videos available on the World Wide Web have been posted with the intention of being an educational resource and therefore perhaps some should not be assessed in this way. Conversely, videos posted on renowned educational resources are likely to be highly edited hindering the use of a safety assessment tool.

There is currently no standard accreditation or regulation for medical videos as training resources. Some of the resources reviewed (WebSurg and ORLive) have signed up to the HONCode [29] a code of conduct for medical and health websites. However, this applies to all online content, is not specific for audiovisual material and does not exclude resources with commercial funding. WebSurg also self-regulates its content with a rigorous peer review process and is affiliated with IRCAD-EITS (Research Institute against Digestive Cancer—European Institute of Telesurgery, University of Strasbourg) world renowned center for minimally invasive surgery training [19].

Our study demonstrates that there is a huge resource of potentially educational material available online for free; however, this is currently not regulated. These findings highlight the need for guidelines for online published laparoscopic videos to enable trainees to identify those resources most useful in a jungle of choices [18, 21]. The authors recommend attention to both selection of safely performed procedures and the educational content provided. Demonstration of theatre set-up, including panoramic views of the operating room showing the position of the patient, surgeon and assistants, is mandatory as English language commentary and case information, including patient's details, postoperative follow-up and histopathological assessment. The use of snapshots and diagrams facilitates the recognition of anatomy and should be considered as the division of the procedure in different steps. Recognized surgical colleges, associations and societies could play a role in regulating this by recommending trusted resources to their trainee bodies.

In this review, we have not explored what trainees or trainers feel are the most useful features of laparoscopic videos for training and maintaining skills. This could be valuable and a Delphi study could be undertaken with surgical trainees and trainers to establish consensus. This could lead to the development of a checklist or guideline to facilitate trainees in selecting the best videos for their needs and to aid publishers of videos to include the most educational information possible.

Conclusion

Laparoscopic videos can be a useful adjunct to clinical and operative training. There is a large and increasing amount of material available for free on the internet, but this is currently unregulated. There is scope for an accreditation process or set of ideal standards to enable trainees to navigate these resources to select those videos with the best educational content.

Acknowledgements The authors declare no fundings were received for the preparation of the manuscript.

Compliance with ethical standards

Disclosures V. Celentano, M. Browning, C. Hitchins, M. C. Giglio, and M. G. Coleman have no conflicts of interest or financial ties to disclose.

References

1. Kerr B, O'Leary JP (1999) The training of the surgeon: Dr. Halsted's greatest legacy. Am Surg 65:1101–1102
2. Varley I, Keir J, Fagg P (2006) Changes in caseload and the potential impact on surgical training: a retrospective review of one hospital's experience. BMC Med Educ 6:6
3. Bell RH, Biester TW, Tabuenca A et al (2009) Operative experience of residents in US general surgery programs: a gap between expectation and experience. Ann Surg 249:719–724
4. Guillou PJ, Quirke P, Thorpe H 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
5. Faiz O, Warusavitarne J, Bottle A et al (2009) Laparoscopically assisted vs. open elective colonic and rectal resection: a comparison of outcomes in English National Health Service Trusts between 1996 and 2006. Dis Colon Rectum 52:1695–1704
6. Miskovic D, Ni M, Wyles SM et al (2012) Learning curve and case selection in laparoscopic colorectal surgery: systematic review and international multicenter analysis of 4852 cases. Dis Colon Rectum 55:1300–1310
7. Kim J, Edwards E, Bowne W et al (2007) Medial-to-lateral laparoscopic colon resection: a view beyond the learning curve. Surg Endosc 21:1503–1507
8. Scott DJ, Young WN, Tesfay ST et al (2001) Laparoscopic skills training. Am J Surg 182:137–142
9. Stein S, Stulberg J, Champagne B (2012) Learning laparoscopic colectomy during colorectal residency: what does it take and how are we doing? Surg Endosc 26:488–492
10. Celentano V, Finch D, Forster L et al (2015) Safety of supervised trainee performed laparoscopic surgery for inflammatory bowel disease. Int J Colorectal Dis 30:639–644
11. Ozyurda F, Dökmeci F, Palaoğlu O et al (2002) The role of interactive training skills courses in medical education at the Ankara University School of Medicine. Teach Learn Med 14:189–193
12. Nageswari KS, Malhotra AS, Kapoor N et al (2004) Pedagogical effectiveness of innovative teaching methods initiated at the Department of Physiology, Government Medical College, Chandigarh. Adv Physiol Educ 28:51–58
13. McEwen A, Moorthy C, Quantock C et al (2007) The effect of videotaped preoperative information on parental anxiety during anesthesia induction for elective pediatric procedures. Paediatr Anaesth 17:534–539
14. Saab BR, Usta J, Major S et al (2009) Impact of a communication skills audiovisual package on medical students' knowledge. J Med Liban 57:226–230
15. Hall JC (2002) Imagery practice and the development of surgical skills. Am J Surg 184:465–470
16. Mukhopadhyay S, Kruger E, Tennant M (2014) YouTube: a new way of supplementing traditional methods in dental education. J Dent Educ 78:1568–1571
17. Fischer J, Geurts J, Valderrabano V et al (2013) Educational quality of YouTube videos on knee arthrocentesis. J Clin Rheumatol 19:373–376
18. Jaffar AA (2012) YouTube: an emerging tool in anatomy education. Anat Sci Educ 5:158–164
19. Dinscore A, Andres A (2010) Surgical videos online: A survey of prominent sources and future trends. Med Ref Serv Q 29:10–27
20. Singh AG, Singh S, Singh PP (2012) YouTube for information on rheumatoid arthritis–a wakeup call? J Rheumatol 39:899–903
21. Duncan I, Yarwood-Ross L, Haigh C (2013) YouTube as a source of clinical skills education. Nurse Educ Today 33:1576–1580
22. Mackenzie H, Ni M, Miskovic D et al (2015) Clinical validity of consultant technical skills assessment in the English National Training Programme for Laparoscopic Colorectal Surgery. Br J Surg 102(8):991–7
23. Miskovic D, Ni M, Wyles SM et al (2013) Is competency assessment at the specialist level achievable? A study for the national training programme in laparoscopic colorectal surgery in England. Ann Surg 257:476–482
24. Mullins JK, Borofsky MS, Allaf ME et al (2012) Live robotic surgery: are outcomes compromised? Urology 80:602–607
25. Kallmes DF, Cloft HJ, Molyneux A et al (2011) Live case demonstrations: patient safety, ethics, consent, and conflicts. Lancet 377:1539–1541
26. Khan SA, Chang RT, Ahmed K et al (2014) Live surgical education: a perspective from the surgeons who perform it. BJU Int. doi:10.1111/Bju.12283 **[1464–410X (Electronic), LID]**

27. Duty B, Okhunov Z, Friedlander J et al (2012) Live surgical demonstrations: an old, but increasingly controversial practice. Urology 79:e7–e11
28. Challacombe B, Weston R, Coughlin G et al (2010) Live surgical demonstrations in urology: valuable educational tool or putting patients at risk? BJU Int 106:1571–1574
29. Health on the net foundation. The HON Code of Conduct for medical and health Web sites (HONcode). Available at https://www.healthonnet.org/

Publication n. 7

Celentano, V., Pellino, G., Coleman, M.G. (2019). Lack of online video educational resources for open colorectal surgery training. *ANZ J Surg*. 2019 Mar;89(3):180-183.

ANZJSurg.com

Lack of online video educational resources for open colorectal surgery training

Valerio Celentano,*† Gianluca Pellino‡ and Mark G. Coleman§¶
*Minimally Invasive Colorectal Unit, Portsmouth Hospitals NHS Trust, Portsmouth, UK
†University of Portsmouth, Portsmouth, UK
‡Department of Medical, Surgical, Neurological, Metabolic, and Ageing Sciences, University of Campania "Luigi Vanvitelli", Naples, Italy
§Colorectal Unit, Plymouth Hospitals NHS Trust, Plymouth, UK and
¶Plymouth University Peninsula School of Medicine and Dentistry, Plymouth, UK

Key words
colorectal surgery, distance learning, open surgery, surgical training, surgical videos.

Correspondence
Dr Valerio Celentano, Minimally Invasive Colorectal Unit, Portsmouth Hospitals NHS Trust, Southwick Hill Road, Portsmouth PO6 3LY, UK.
Email: valeriocelentano@yahoo.it

V. Celentano MD, FRCS; **G. Pellino** MD, PhD; **M. G. Coleman** MD, FRCS.

Accepted for publication 27 December 2018.

doi: 10.1111/ans.15077

Abstract

Background: Video recordings of open surgical procedures could provide a method for enhancing surgical education, analysing operative performance and presenting cases to a wider audience of surgeons. The aim of this pilot study was to systematically search the World Wide Web to determine the availability of open surgery videos and to evaluate their potential training value in terms of the educational content presented.
Methods: A broad search for open right hemicolectomy videos was performed on the three most used English language internet search engines (Google.com, Bing.com and Yahoo.com). All videos of open right hemicolectomy with an English language title were included. Laparoscopic surgery, single-incision laparoscopic surgery and robotic- and hand-assisted surgery videos were excluded, as were videos from fee charging websites.
Results: A total of 31 relevant websites were identified and 21 open surgery videos were finally included. The characteristics of the patients were presented only in four (19%) videos. A video commentary was present in 12 cases (57.1%) and this was in English language in 11. The median number of views per month was 84.1.
Conclusions: Open surgery videos have a significantly higher number of views per month compared to laparoscopic surgery videos, but current methodologies used to record and render the surgeon's point of view in open operative surgery remain limited.

Introduction

The teaching of surgical skills has traditionally followed an apprentice model with trainees frequently receiving one-to-one training;[1] however, major changes from this model have evolved as a response to restricted working hours brought on by the implementation of European Union Working Time Directive.[2] The operating room represents an essential learning environment which cannot be fully replaced, but with duty hour restrictions, surgical trainees may have less autonomy and educational time in the operating room.[3] As a consequence, the problem of how to make education more efficient has taken on greater importance.

Audio-visual presentations are considered as important educational materials in the medical field[4] and are used to communicate information effectively to clinicians, patients and students.[5,6] Recent studies demonstrate that videos are increasingly applied for distance learning in surgery,[7] but the trustworthiness of a large proportion of publicly available files remains questionable as not all videos are authoritative and may not show techniques based on solid evidence and contain incorrect or misleading promotional information.[8,9]

Minimally invasive surgery naturally lends itself to production of audio-visual material[10] as the operative camera can be streamed to provide learners both in and out of the operating room, with the surgeon's point of view.[11] Open surgery, however, presents obstacles to distance learning, due to the difficulty in mounting cameras to provide the surgeon's perspective. Although many hospitals provide video-recording services, significant improvements can still be made in this area, particularly in capturing high-quality video recordings.[12]

Video recordings of open surgical procedures could provide a method for enhancing surgical education, analysing operative performance and presenting cases to a wider audience of surgeons. The aim of this study is to systematically search the World Wide

Web to determine the availability of open colorectal surgery videos and to evaluate their potential training value in terms of the educational content presented.

Methods

Search strategy

According to a previously developed review protocol,[8] a broad search for open right hemicolectomy videos was independently performed by two authors on the three most used English language internet search engines (Google.com, Bing.com and Yahoo.com) using the keywords ‘open colorectal surgery video’ and ‘right hemicolectomy video’.

The first 100 results of each search were considered and all websites containing surgical videos were assessed. Sponsored links, advertisements and surgeons’ private practice websites were not considered. Moreover, in order to include as many websites as possible, reflecting the actual use of internet by trainees, a survey among 25 local trainees was performed to identify further websites for inclusion.

All retrieved websites were systematically searched for open right hemicolectomy videos using the following search terms: right hemicolectomy, right colectomy, open colectomy and colorectal surgery. When a browse function of the available videos was present on the website, right hemicolectomy videos were retrieved manually. The last search was run on 22 October 2017.

Eligibility criteria and video selection

All videos of open right hemicolectomy with an English language title were included. Laparoscopic surgery, single-incision laparoscopic surgery and robotic- and hand-assisted surgery videos were excluded, as were videos from fee charging websites. Videos only demonstrating the anastomosis or the use of a new device for a single step of the procedure were excluded.

Two reviewers independently assessed the videos for eligibility at title level. The inter-reviewer’s agreement was explored through the Cohen’s Kappa statistic. In case of discrepancies, a third author was consulted and agreement was reached by consensus.

When the same author and institution published the same video on different websites, only the most recent video was evaluated.

Data extraction

Two authors independently retrieved the data from each included video completing an electronic database with the records detailed in Table 1.

Statistical analysis

Categorical data are presented as frequency counts and associated percentages; comparisons were made by means of Pearson’s chi-squared test. Continuous data are presented as medians and ranges and were compared by using the Wilcoxon rank sum test. A *P*-value of ≤0.05 was considered to be statistically significant. Statistical analyses were performed using STATA 12 statistical software (StataCorp, College Station, TX, USA).

Table 1 Data extracted from the included videos

Video characteristics	Date uploaded
	Country
	Total number of views and 30-day views
	Video length, full length or edited
Image quality	High definition
	Amount of time video affected by poor quality image
Supplementary educational content	Presence of audio or written commentary
	Use of diagrams and screenshots
	Procedure divided in steps
	Formal case presentation
	Preoperative imaging
Patient details	Age
	Sex
	BMI
	Indication for surgery
	Co-morbidities, ASA score
	Previous surgery
Outcomes	Total operating time
	Intraoperative complications
	Estimated blood loss
	30-day morbidity
	Length of hospital stay

ASA, American Society of Anesthesiologists classification; BMI, body mass index.

Results

Search results

A total of 31 relevant websites (Appendix S1) were identified and 41 videos were retrieved, five duplicates and two videos not available for free were excluded. After the exclusion of five laparoscopic videos, four videos demonstrating a different procedure and four videos only demonstrating the anastomosis, 21 open surgery videos were finally included (Appendix S2). The Kappa statistic showed a high (κ = 0.94) agreement between reviewers on videos’ selection.

Video characteristics

None of the videos were available in high definition, while 11 videos provided authors’ information (52.4%). Only four videos (19%) were recorded in full length as vast majority of the videos were edited or truncated. Median video length was 7 min and 43 s (range 2:33–77:52). A video commentary was present in 12 cases (57.1%) and this was in English language in 11. The median number of views per month was 84.1 (range 3.7–2500).

Patient characteristics and outcome of the procedure

Indication for surgery was reported in 17 videos (81%) and this was cancer in 14 of them. The characteristics of the patients were presented only in four (19%) videos. The American Society of Anesthesiologists (ASA) score, body mass index and history of previous surgery were never mentioned. Preoperative imaging was demonstrated in four videos (19%), whereas none of the videos reported estimated blood loss and 30-day morbidity. Only two videos (9.5%) reported length of hospital stay. When indication for surgery was cancer, the final histology was reported in only one case.

Educational content

A step-by-step approach was used to demonstrate the main passages of the surgical procedure in 10 videos (47.6%). Only one video integrated tables to show additional content, while snapshots and pictures were used to demonstrate the anatomy in five cases (23.8%).

Discussion

This pilot study demonstrates that there are limited online resources for open colorectal surgery videos. We found only 21 open right hemicolectomy videos available online after searching, with no limitation on the year of publication, on 31 of the websites most used by surgical trainees.[13] When performing laparoscopic or other minimally invasive surgery, video capture is not usually an issue, as current endoscopy systems are equipped with video-recording devices making it relatively easy to capture high-quality images in a digital format, with the video recording of the procedure showing exactly what the surgeon is viewing providing surgical trainees with essential information regarding anatomy and the different steps of the operation.[14] Not surprisingly, a previous study[8] demonstrated that 140 laparoscopic right hemicolectomy videos were published on the same online resources only in a 5-year period from 2011 to 2015. Nevertheless, open surgery videos have a significantly higher number of views per month compared to laparoscopic surgery, as the median number of monthly views was 84.1 (range 3.7–2500) for open right hemicolectomy videos compared to 34.6 (range 0.2–979) for laparoscopy.

With the increasing availability of recording devices in operating rooms, video-based demonstrations and analyses could provide a valuable aid to the diffusion and assessment of surgical skills,[15] and courses including live surgical demonstrations are becoming increasingly popular and considered to be useful not only for trainees but also for the independently practicing surgeons as an effective source of continuing medical education.[16] Unfortunately, current methodologies used to record and render the surgeon's point of view in open operative surgery remain limited.[17]

Many operating rooms are equipped with video cameras mounted in the handle of the operating light. Although these may also be suitable for recording surgical procedures on the body surface, they are of variable quality, particularly when challenged in deep body cavities, and do not usually have a digital interface. Head-mounted cameras and consumer video cameras cannot capture high contrast video as they often require diversion of the operating light away from the operative field to avoid overexposure of the image. Even those consumer cameras with low-light recording capabilities cannot record in low-light conditions without loss of contrast and loss of resolution. Lack of sterility can limit the utility of these methods of video capture, and in addition, head-mounted and handheld cameras can suffer from unsteady images, while handheld or tripod-mounted cameras can obstruct the scene to other members of the surgical team.

Our study has some limitations. Only websites mentioned in the first 100 results from each search were extracted. We know that the results with the most hits does not always mean the best quality;[18] however, 100 is a large number and therefore likely to be representative of the resources available. We faced the challenge of searching for scientific content on resources not specifically designed for this purpose, shifting from medical databases commonly used for systematic reviews, to websites designed for video sharing. Acknowledging this is as important as it is to note that the search strategy we used is more likely to reproduce how surgical trainees search for video educational material, which is the main focus of our study, as demonstrated by the additional trainees' survey we performed to minimize the risk of missing data.

Our study demonstrates that there is significant lack of educational open colorectal surgery videos available to trainees. Open surgery videos could be used not only as a teaching aid but also for retrospective self-assessment of the performed procedure by surgical trainees.[19] For these reasons, despite the described difficulties in obtaining good quality video recordings, recognized surgical colleges, associations and societies should play a role in commissioning and sharing open surgery videos. Attention should be given to additional educational content, including demonstration of theatre set-up, the position of the patient and theatre team, English language commentary and case information, such as patient's details, post-operative follow-up and histopathological assessment. The use of snapshots and diagrams facilitates the recognition of anatomy and should be considered as the division of the procedure in different steps.

Conclusion

Open surgery videos have a significantly higher number of views per month compared to laparoscopic surgery videos, but current methodologies used to record and render the surgeon's point of view in open operative surgery remain limited. Our study found a limited number of open colorectal surgery videos with minimal educational content.

Conflicts of interest

None declared.

References

1. Kerr B, O'Leary JP. The training of the surgeon: Dr. Halsted's greatest legacy. *Am. Surg.* 1999; **65**: 1101–2.
2. European Union. Employment rights and work organisation. Available from URL: http://europa.eu/legislation_summaries/employment_and_social_policy/health_hygiene_safety_at_work/c10418_en.htm
3. Nesbitt C, Phillips AW, Searle R, Stansby G. Student views on the use of 2 styles of video-enhanced feedback compared to standard lecture feedback during clinical skills training. *J. Surg. Educ.* 2015; **72**: 969–73.

4. Nageswari KS, Malhotra AS, Kapoor N, Kaur G. Pedagogical effectiveness of innovative teaching methods initiated at the Department of Physiology, Government Medical College, Chandigarh. *Adv. Physiol. Educ.* 2004; **28**: 51–8.
5. McEwen A, Moorthy C, Quantock C, Rose H, Kavanagh R. The effect of videotaped preoperative information on parental anxiety during anesthesia induction for elective pediatric procedures. *Paediatr. Anaesth.* 2007; **17**: 534–9.
6. Saab BR, Usta J, Major S, Antoun J. Impact of a communication skills audiovisual package on medical students' knowledge. *J. Med. Liban.* 2009; **57**: 226–30.
7. Celentano V, Smart N, McGrath J *et al.* LAP-VEGaS practice guidelines for reporting of educational videos in laparoscopic surgery: a Joint Trainers And Trainees Consensus Statement. *Ann. Surg.* 2018; **268**: 920–6.
8. Celentano V, Browning M, Hitchins C, Giglio MC, Coleman M. Training value of laparoscopic colorectal videos on the World Wide Web: a pilot study on the educational quality of laparoscopic right hemicolectomy videos. *Surg. Endosc.* 2017; **31**: 4496–504.
9. Singh AG, Singh S, Singh PP. YouTube for information on rheumatoid arthritis – a wakeup call? *J. Rheumatol.* 2012; **39**: 899–903.
10. Challacombe B, Wheatstone S. Telementoring and telerobotics in urological surgery. *Curr. Urol. Rep.* 2010; **11**: 22–8.
11. Cubano M, Poulose BK, Talamini MA *et al.* Long distance telementoring. A novel tool for laparoscopy aboard the USS Abraham Lincoln. *Surg. Endosc.* 1999; **13**: 673–8.
12. Cosman PH, Shearer CJ, Hugh TJ, Biankin AV, Merrett ND. A novel approach to high definition, high-contrast video capture in abdominal surgery. *Ann. Surg.* 2007; **245**: 533–5.
13. Celentano V, Smart N, Cahill RA *et al.* Use of laparoscopic videos amongst surgical trainees in the United Kingdom. *Surgeon* 2018. https://doi.org/10.1016/j.surge.2018.10.004.
14. Hall JC. Imagery practice and the development of surgical skills. *Am. J. Surg.* 2002; **184**: 465–70.
15. Glarner CE, Hu YY, Chen CH *et al.* Quantifying technical skills during open operations using video-based motion analysis. *Surgery* 2014; **156**: 729–34.
16. Mullins JK, Borofsky MS, Allaf ME *et al.* Live robotic surgery: are outcomes compromised? *Urology* 2012; **80**: 602–7.
17. O'Leary DP, Deering-McCarthy E, McGrath D, Walsh D, Coffey JC. Identification of the optimal visual recording system in open abdominal surgery – a prospective observational study. *J. Vis. Commun. Med.* 2016; **39**: 127–32.
18. Jaffar AA. YouTube: an emerging tool in anatomy education. *Anat. Sci. Educ.* 2012; **5**: 158–64.
19. Davis DA, Mazmanian PE, Fordis M, Van Harrison R, Thorpe KE, Perrier L. Accuracy of physician self-assessment compared with observed measures of competence: a systematic review. *JAMA* 2006; **296**: 1094–102.

Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix S1. Websites searched for right hemicolectomy videos.
Appendix S2. Open right hemicolectomy videos.

Publication n. 8

Celentano, V., Smart, N., Cahill, R.A., McGrath, J.S., Gupta, S., Griffith, J.P., Acheson, A.G., Cecil ,T.D., Coleman, M.G. (2018). Use of laparoscopic videos amongst surgical trainees in the United Kingdom. *Surgeon*. 2018 Nov 9. pii: S1479-666X(18)30123-9.

Use of laparoscopic videos amongst surgical trainees in the United Kingdom

Valerio Celentano [a,b,*], Neil Smart [c], Ronan A. Cahill [d,e], John S. McGrath [f,g], Sharmila Gupta [h], John P. Griffith [i], Austin G. Acheson [j,k], Tom D. Cecil [l], Mark G. Coleman [m,n]

[a] Department of Colorectal Surgery, Queen Alexandra Hospital, Portsmouth Hospitals NHS Trust, Portsmouth, United Kingdom
[b] University of Portsmouth, Portsmouth, United Kingdom
[c] Exeter Health Services, Research Unit, Royal Devon & Exeter Hospital, United Kingdom
[d] Colorectal Unit, Mater Misericordiae University Hospital, Dublin, Ireland
[e] Section of Surgery and Surgical Specialities, School of Medicine, University College Dublin, Ireland
[f] Department of Urology, Royal Devon and Exeter NHS Trust, United Kingdom
[g] University of Exeter Medical School, Exeter, United Kingdom
[h] Department of Colorectal Surgery, Colchester Hospital NHS Foundation Trust, Colchester, United Kingdom
[i] Colorectal Unit. Bradford Teaching Hospitals NHS Foundation Trust. Bradford, United Kingdom
[j] School of Clinical Sciences, University of Nottingham, Nottingham, United Kingdom
[k] National Institute for Health Research (NIHR) Nottingham Biomedical Research Centre, Nottingham University Hospitals NHS Trust and University of Nottingham, Nottingham, United Kingdom
[l] Peritoneal Malignancy Institute, Basingstoke, United Kingdom
[m] Department of Colorectal Surgery, Plymouth Hospitals NHS Trust, Plymouth, United Kingdom
[n] Plymouth University - Peninsula School of Medicine & Dentistry, Plymouth, United Kingdom

ARTICLE INFO

Article history:
Received 21 July 2018
Received in revised form
9 October 2018
Accepted 14 October 2018
Available online xxx

Keywords:
Laparoscopic surgery
Surgical videos
Distance learning
Surgical training

ABSTRACT

Background: Surgical trainers consider laparoscopic videos as a useful teaching aid to maximize trainees' learning and skill development given the backdrop of time constraints and productivity demands. Aim of this study is to assess the current use of laparoscopic videos amongst surgical trainees in the United Kingdom.

Methods: A steering committee of 15 experienced laparoscopic trainers from 8 countries developed a survey on the use of laparoscopic videos by surgical trainees. The survey items were finalized by discussion through e-mails, teleconferences, and face-to-face meetings and a finalised questionnaire was distributed amongst surgical trainees in the United Kingdom.

Results: 92 trainees were invited and 75 returned the questionnaire (81.5%). 86.7% of the trainees routinely watched online surgical videos and the more frequently used websites were Youtube.com and Websurg.com. Trainees require laparoscopic videos to have supplementary educational content such as English commentary (90.7%) and use of snapshots (93.3%) and diagrams (86.7%). Position of the patient and trocars, indication for surgery, preoperative data and postoperative outcomes are required characteristics of laparoscopic videos. 29 trainees (38.7%) do not record the laparoscopic procedures they perform, despite the majority of them recognising the usefulness of routine video-recording for training purposes (78.7%).

Conclusions: Surgical trainees consider videos a useful adjunct in laparoscopic surgery training, with preference for open access sources. Trainees value highly informative videos with supplementary educational content.

* *Corresponding author*. Consultant Colorectal Surgeon - Portsmouth Hospitals NHS Trust, Honorary Senior Lecturer – University of Portsmouth, Portsmouth, United Kingdom.
E-mail address: valeriocelentano@yahoo.it (V. Celentano).
https://doi.org/10.1016/j.surge.2018.10.004

Please cite this article in press as: Celentano V, et al., Use of laparoscopic videos amongst surgical trainees in the United Kingdom, The Surgeon (2018), https://doi.org/10.1016/j.surge.2018.10.004

Introduction

Trainee surgeons are required to gather more technical skills in a shorter time period[1] and a deficiency of successful performance of enough critical laparoscopic cases by trainees has been demonstrated.[2,3] The proportion of operations undertaken by surgical trainees has reduced in the past decade[4] as they spend less time in theatre and more time covering night shifts and care of acute admissions.[5,6] The duration of surgical training varies significantly around the world, and trainee working patterns differ, ranging from 48 h per week in Europe[7] to 80 in the USA.[8] The lack of worldwide standardization of expected operative experience in general surgical training with different requirements of surgical curricula is likely to influence the opportunities for gaining experience with the potential for wide variation in the operative exposure of newly qualified surgeons around the world.[9] Consequently, it has become widely accepted that surgeons must develop new innovative methods of surgical training[10,11] outside of the surgical theatre[12] to abbreviate the learning curve and potentially further enhance patient safety.

Audio-visual presentations are recognized in the medical field as important educational materials; thus, they are used to communicate information effectively to clinicians, patients and students.[13,14] Fortunately, laparoscopic surgery lends itself to the production of audio-visual educational materials, with current laparoscopic systems equipped with video-recording devices, making it easy to capture high-quality images in a digital format. Recent studies suggest that these sources hold promise as educational tools for scientific disciplines,[15] but the trustworthiness of a large proportion of publicly available files remains questionable as not all videos are authoritative and may not show techniques based on solid evidence. Furthermore they may contain incorrect or misleading promotional information.[16,17] Instructive laparoscopy videos with appropriate exposition could therefore be ideal for initial training in laparoscopic surgery[18] and can be produced even with minimal prior video editing experience.[19] Surgical trainers consider laparoscopic videos as a useful teaching aid[20] to maximize trainees' learning and skill development given the backdrop of time constraints and productivity demands.[21] The aim of this study is to assess the current use of laparoscopic videos amongst surgical trainees in the United Kingdom.

Methods

A steering committee consisting of 15 experienced laparoscopic trainers from eight countries developed a survey on the use of laparoscopic videos by surgical trainees. The survey items were finalized by discussion through e-mails, teleconferences, and face-to-face meetings. Based on the results of the discussion; the steering committee prepared an anonymised questionnaire which was distributed amongst surgical trainees in the UK willing to take part to the study and sampled from the trainers' units using an electronic survey tool (Enalyzer, Denmark, www.enalyzer.com), over a period of 6 months from July 2016 to January 2017. A second round of questionnaires was sent to junior trainees who had not previously participated between December 2017 and June 2018.

After completion of a two-year postgraduate Foundation programme, the UK surgical training pathway is structured with a two-year 'Core Surgical Training' programme, followed by six-year 'Specialist Training' programme.[22] The Joint Committee on Surgical Training (JCST) is responsible for curriculum development and quality assurance of all the surgical training programmes, and the end of training is marked by the award of a 'certificate of completion of training' (CCT), which requires completion of the intercollegiate fellowship examinations, completion of surgical training competency based assessments, demonstration of management and leadership skills and logbook evidence as outlined by the JCST.[23]

Trainees were invited via email, and were considered eligible for inclusion in the survey if they had completed a core surgical training programme and if they were currently enrolled, or planning to be, into a specialist surgical training programme in the United Kingdom with interest in pursuing a career in colorectal surgery, oesophagogastric surgery, hepatobiliary or general surgery.

Categorical variables are presented as frequency or percentage and were compared with the use of the chi-square test or Fisher's exact test, as appropriate. Continuous variables are presented as means (±standard deviation) and were compared with the use of Student's t test. The Mann–Whitney U test was used for continuous, not normally distributed, outcomes.

Results

A total of 92 UK trainees (70 in the first round and 22 in the second round) were invited and 75 returned the questionnaire (81.5%). 41 were males (54.7%) and 34 females (45.3%). The number of years trainees had spent in speciality training, after completion of foundation year and core surgical training, was 1 in 18 cases (24%), 2 in 17 (22.7%), 3 in 11 (14.7%), 4 in 7 (9.3%), 5 in 8 (10.7%) and 6 in 7 (9.3%). Seven trainees (9.3%) who had completed core surgical training but not obtained yet a higher surgical training placement were also included.

64 trainees (86.7%) routinely watched online laparoscopic surgical videos, and the most frequently accessed websites (Fig. 1) were YouTube (http://www.youtube.com) and Websurg (http://www.websurg.com). Trainees preferred laparoscopic videos to have supplementary educational content

Please cite this article in press as: Celentano V, et al., Use of laparoscopic videos amongst surgical trainees in the United Kingdom, The Surgeon (2018), https://doi.org/10.1016/j.surge.2018.10.004

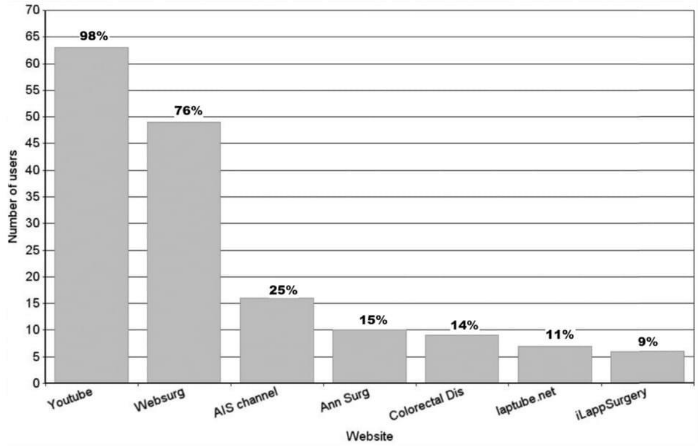


Figure 1 – Number of users of online resources for laparoscopic surgical videos. The numbers above each bar indicate the percentage of respondents that use each of the online resources. Every trainee had the opportunity to indicate up to 3 resources.

such as English commentary (90.7%) and the use of snapshots (93.3%) and diagrams (86.7%) to demonstrate the anatomy. Surgical trainees are interested in videos showing not only surgical details such as the position of the patient and trocars (100%), but also the indication for surgery (96%), pre-operative data (body mass index 92%, previous surgical history 98.7%) and post-operative outcomes (length of hospital stay 80%, 30-day morbidity 94.6%), as summarized in Table 1. The characteristics of the videos found online by the surgical trainees are detailed in Table 2. 14 trainees (21.9%) do not know if the videos they watch online have undergone peer review prior to publication and 5 trainees (7.8%) do not even know if the videos have undergone prior editing, suggesting that some of the trainees might be superficial users of online laparoscopic surgery videos, that could explain some of the disparities between the videos trainees claim to prefer and the ones they actually watch.

33 trainees (41.3%) had dedicated briefing and debriefing sessions with their trainer(s) in elective theatre lists and only in 9 cases trainers used scoring system to critically evaluate the procedure performed by the trainees. Only 46 trainees out of 75 (61.3%) video-record the laparoscopic procedures they perform, despite 59 trainees (78.7%) recognising that it could be useful reviewing the videos of the laparoscopic procedures performed and 64 trainees (85.3%) stating that they would like attending dedicated video review sessions with peers and trainers. 22 of the 46 trainees who video-record the laparoscopic procedures they perform review the video on their own (47.8%), while 6 with peers (12.5%) and 18 with the trainer (39.1%).

Discussion

Our study demonstrates that surgical trainees in the UK use online laparoscopic videos as an educational tool. Trainees value highly informative videos detailing patients' characteristics and surgical outcomes, and integrated with supplementary educational content such as snapshots and diagrams to facilitate the recognition of anatomy and division of the procedure into modular steps. Written commentary is particularly beneficial for people watching videos in their non-native language,[24] which could also be relevant for distance mentoring and proctoring of surgeons introducing a new technique in a different country.

We also acknowledge that trainees use open access sources such as YouTube.com more frequently than peer reviewed sources, despite recognising that the latter offer videos with more educational content. YouTube is an ideal platform for educational presentations providing easy sharing of videos, which are streamed in different resolution qualities, allowing for easy viewing on a multitude of devices including the personal computer, handheld media players and smart phones.[25] However, the widespread use of YouTube might reflect the concerning trend observed in the last few years,[26] with more videos being shared without undergoing a formal peer-review process, with limited educational content and lack of information on patients' data, indication for surgery and surgical outcomes such morbidity and histopathological assessment. On the basis of these premises, an international, multi-specialty, joint trainers-trainees committee recently developed consensus statement on how to report a laparoscopic surgery video for educational purposes (LAP-VEGaS: LAParoscopic surgery Video Educational GuidelineS) with the aim to reduce the gap between trainees' expectations and online resources' quality,[27] as adherence to the guidelines could help improve the educational value of video materials when used for the purposes of training, as well as providing a template for critical appraisal and review of videos submitted for publication.

Please cite this article in press as: Celentano V, et al., Use of laparoscopic videos amongst surgical trainees in the United Kingdom, The Surgeon (2018), https://doi.org/10.1016/j.surge.2018.10.004

Table 1 – Essential information required by surgical trainees in educational laparoscopic videos.

	YES, n(%)	NO, n(%)	Don't know, n(%)	No answer, n(%)
Patient characteristics				
Indication for surgery	72 (96%)	0	1 (1.3%)	2 (2.7%)
Age of the patient	75(100%)	0	0	0
Sex of the patient	75 (100%)	0	0	0
ASA score	59 (78.7%)	8 (10.6%)	6 (8%)	2 (2.7%)
Comorbidities	57 (76%)	5 (6.7%)	8 (10.6%)	5 (6.7%)
Body Mass Index	69 (92%)	5 (6.7%)	1 (1.3%)	0
Previous surgery	74 (98.7%)	0	0	1 (1.3%)
Preoperative imaging	71 (94.6%)	2 (2.7%)	0	2 (2.7%)
Preoperative work up	60 (80%)	6 (8%)	3 (4%)	6 (8%)
Surgical outcomes				
Operating time	63 (84%)	8 (10.6%)	4 (5.3%)	0
Length of hospital stay	60 (80%)	13 (17.3%)	1 (1.3%)	1 (1.3%)
Blood loss	69 (92%)	4 (5.3%)	1 (1.3%)	1 (1.3%)
30-day morbidity	71 (94.6%)	2 (2.7%)	2 (2.7%)	0
Histology	68 (90.7%)	4 (5.3%)	2 (2.7%)	1 (1.3%)
Follow-up duration and outcomes	51 (68%)	16 (21.3%)	5 (6.7%)	3 (4%)
Educational content				
The procedure should be presented in a step by step fashion	73 (97.3%)	0	1 (1.3%)	1 (1.3%)
Position of the ports	75 (100%)	0	0	0
Position of the patient	75(100%)	0	0	0
Position of extraction site	71 (94.7%)	4 (5.3%)	0	0
Open part of the procedure demonstrated	47 (62.7%)	13 (17.3%)	11 (14.7%)	4 (5.3%)
Audio/written English commentary	68 (90.7%)	3 (4%)	4 (5.3%)	0
Use of snapshots	70 (93.3%)	1 (1.3%)	2 (2.7%)	2 (2.7%)
Use of diagrams	65 (86.7%)	8 (10.7%)	1 (1.3%)	1 (1.3%)

ASA: American Society of Anaesthesiologists.

Technical competency is dependent on supervised training volume,[28] which is consistent with the theory of deliberate practice, indicating that expertise is not related exclusively to the volume of experience but to time spent practising with constructive feedback.[29] Therefore, technical competence should be based on objective assessment of the quality of performance rather than the number of procedures performed and video-based learning should not only be limited to watching a procedure performed by another surgeon, but also include appraising the trainees' own performance, by reviewing the video with peers and trainers. Given that feedback has been demonstrated to improve performance,[30] this should be a fundamental part of training in advanced laparoscopic surgery, despite it being a shift from the more traditional method of surgical teaching.[31] Surprisingly, 29 of the 75 trainees who answered our survey declared they do not routinely record the laparoscopic procedure they perform with only 18 trainees reviewing the video with the trainer in a feedback session and objective scoring systems only being used in nine cases, which is a concerning finding of lack of reflective practice based on objective performance. Consistent review of surgical videos could facilitate understanding of common errors in order to create awareness of potential injury mechanisms by acknowledging error-event patterns[32] and by engaging with online content through informal interactions[33] including peer discussion facilitated via social media, which can provide an important component of surgeons' ongoing development by shared experiential learning and knowledge.[34]

Social media is becoming an increasingly popular component of modern-day surgical practice[33] and Twitter (http://www.twitter.com) has been found to be the most popular app on surgeons' mobile phones[35] with peer-reviewed journals disseminating new research online[36,37] and surgical societies live tweeting to increase engagement at events and conferences.[38] Our study focused on the use of online websites by trainees, potentially excluding the content which can be found on other social media platforms, with examples including Linkedin (http://www.linkedin.com), a business and employment social network, and growing Facebook (http://www.facebook.com) closed groups[34] such as the International Hernia Collaboration[39] and Robotic Surgery Collaboration[40] where high quality video content is shared and live peer reviewed amongst more than 5000 group members.

Higher surgical training in General surgery, with access to specialty training, is a national recruitment system in the United Kingdom, which can be accessed by surgical trainees who have completed the foundation year programme (duration of 2 years), and the core surgery training programme (duration of 2 years). In order to direct our survey to a homogeneous sample of trainees committed to general surgery training, we decided to exclude trainees who had not completed yet core surgical training, as some of them might decide to opt for different specialties such as orthopaedics or plastic surgery, which do not involve laparoscopic surgery. Addressing our survey to a group of more senior trainees, committed to a career in general surgery, minimised the risk of enrolling trainees not using online videos simply because not interested in laparoscopic surgery, but resulted nevertheless in recruiting only 92 trainees, which might not be representative of the whole population of trainees in the United Kingdom, particularly in view of their different levels of experience which may have underpowered subgroup analysis. More importantly, trainees with different levels of experience might be watching videos from different sources being the web content not all similar, with websites preferentially directed towards more senior trainees or independently practising surgeons, who may be less attracted by videos lengthily detailing basic surgical techniques or with a lot of background information. The preliminary findings of our study could guide the development of a more detailed survey with the use of Likert scales to better define the characteristics of laparoscopic video usage amongst surgical trainees, and

Please cite this article in press as: Celentano V, et al., Use of laparoscopic videos amongst surgical trainees in the United Kingdom, The Surgeon (2018), https://doi.org/10.1016/j.surge.2018.10.004

Table 2 – Characteristics of laparoscopic video usage amongst surgical trainees in the UK.

	Yes, n(%)	No, n(%)	I don't know, n(%)
Do you find that all the videos you watch are educational?	46 (71.9%)	18 (28.1%)	0
Do you find differences in the educational value among videos?	60 (93.7%)	4 (6.3%)	0
Do the videos you watch undergo peer review prior to publication?	36 (56.2%) *Always: 1 (1.6%)* *Sometimes: 26 (40.6%)* *Rarely: 9 (14%)*	14 (21.9%)	14 (21.9%)
Did you notice a difference in the educational value between peer reviewed and non-peer reviewed videos?	60 (93.7%)	4 (6.3%)	0
Do you think that peer reviewed videos are more educational?	52 (81.3%)	7 (10.9%)	5 (7.8%)
Do you think that peer reviewed videos present a safer procedure?	54 (84.4%)	4 (6.3%)	6 (9.3%)
Have the videos you watch been edited?	59 (92.2%) *Always: 27 (42.1%)* *Sometimes: 32 (50%)* *Rarely: 0*	0	5 (7.8%)
Do you think watching unedited videos could be more educational?	38 (59.4%)	24 (37.5%)	2 (3.1%)

promotion of the survey by trainees associations could ensure appropriate geographical representation and likely a larger sample size of UK surgical trainees. Another limitation of our study is that teaching surgical techniques also requires non-technical skills, as communication and teamwork have been shown to influence surgical performance,[41,42] while video based learning in surgery mainly addresses technical aspects of the procedure. A more qualitative survey, promoted by surgical societies or trainee associations is desirable, addressing the reasons for lack of engagement with distance learning by some trainees, which could be explained by service provision pressures and time constraints, in case this finding is confirmed.

Conclusion

Surgical trainees consider videos a useful adjunct in laparoscopic surgery training, with preference for open access sources. Trainees value highly informative videos with supplementary educational content. A limited proportion of trainees routinely records and reviews with peers and trainers the surgical procedure they perform.

Disclosures

V Celentano, N Smart, R Cahill, J McGrath, S Gupta, J Griffith, A Acheson, T Cecil and M Coleman have no conflict of interests or financial ties to disclose.

Acknowledgements

The authors declare no funding was received for the preparation of the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.surge.2018.10.004.

REFERENCES

1. Stein S, Stulberg J, Champagne B. Learning laparoscopic colectomy during colorectal residency: what does it take and how are we doing? *Surg Endosc* 2012;**26**:488–92.
2. Bass BL. Matching training to practice: the next step. *Ann Surg* 2006;**243**:436–8.
3. Pugh CM, Darosa DA, Bell RH. Residents' self-reported learning needs for intraoperative knowledge: are we missing the bar? *Am J Surg* 2010;**199**:562–5.
4. Blencowe NS, Parsons BA, Hollowood AD. Effects of changing work patterns on general surgical training over the last decade. *Postgrad Med J* 2011;**87**:795–9.
5. Varley I, Keir J, Fagg P. Changes in caseload and the potential impact on surgical training: a retrospective review of one hospital's experience. *BMC Med Educ* 2006;**6**:6.
6. Taylor IA, Alexander F. *Preface to the ISCP report. ISCP evaluation task group*. 2006. Available from: URL: http://www.mee.nhs.uk/pdf/FinalReportISCP-MichaelEraut.pdf.
7. Independent Working Time Regulations Task Force. the implementation of the working time directive, and its impact on the NHS and health professionals. https://www.rcseng.ac.uk/government-relations-and-consultation/documents/wtd-taskforce-report-2014.
8. Accreditation Council for Graduate Medical Education. Common program requirements. http://www.acgme.org/Portals/0/PDFs/Common_Program_Requirements_07012011[2].pdf.
9. Elsey EJ, Griffiths G, Humes DJ, West J. Meta-analysis of operative experiences of general surgery trainees during training. *Br J Surg* 2017 Jan;**104**(1):22–33.
10. Gurusamy KS, Aggarwal R, Palanivelu L, Davidson BR. Virtual reality training for surgical trainees in laparoscopic surgery. *Cochrane Database Syst Rev* 2009;**21**. CD006575.
11. Scott DJ, Bergen PC, Rege RV, Laycock R, Tesfay ST, Valentine RJ, et al. Laparoscopic training on bench models: better and more cost effective than operating room experience? *J Am Coll Surg* 2000;**191**:272–83.
12. Samia H, Khan S, Lawrence J, Delaney CP. Simulation and its role in training. *Clin Colon Rectal Surg* 2013;**26**:47–55.
13. Ozyurda F, Dökmeci F, Palaoğlu O, Arda B. The role of interactive training skills courses in medical education at the Ankara University School of Medicine. *Teach Learn Med* 2002;**14**:189–93. http://www.scopus.com/inward/citedby.url?eid=2-s2.0-0036615453&partnerID=10&rel=R3.0.0&md5=37373ec8cac033e0873343fd447a15c913.

14. McEwen A, Moorthy C, Quantock C, Rose H, Kavanagh R. The effect of videotaped preoperative information on parental anxiety during anesthesia induction for elective pediatric procedures. *Paediatr Anaesth* 2007;**17**:534–9.
15. Jaffar AA. YouTube: an emerging tool in anatomy education. *Anat Sci Educ* 2012;**5**:158–64.
16. Singh AG, Singh S, Singh PP. YouTube for information on rheumatoid arthritis–a wakeup call? *J Rheumatol* 2012;**39**:899–903.
17. Duncan I, Yarwood-Ross L, Haigh C. YouTube as a source of clinical skills education. *Nurse Educ Today* 2013;**33**:1576–80.
18. Hall JC. Imagery practice and the development of surgical skills. *Am J Surg* 2002;**184**:465–70.
19. Tolerton SK, Hugh TJ, Cosman PH. The production of audiovisual teaching tools in minimally invasive surgery. *J Surg Educ* 2012 May-Jun;**69**(3):404–6.
20. Abdelsattar JM, Pandian TK, Finnesgard EJ, El Khatib MM, Rowse PG, Buckarma EN, et al. Do you see what I see? How we use video as an adjunct to general surgery resident education. *J Surg Educ* 2015 Nov-Dec;**72**(6):e145–50.
21. Gorin MA, Kava BR, Leveillee RJ. Video demonstrations as an intraoperative teaching aid for surgical assistants. *Eur Urol* 2011 Feb;**59**(2):306–7.
22. Writing group, Project steering group, ASiT/BOTA Lost Tribe Study Group. Early years postgraduate surgical training programmes in the UK are failing to meet national quality standards: an analysis from the ASiT/BOTA Lost Tribe prospective cohort study of 2,569 surgical trainees. *Int J Surg* 2018 Apr;**52**:376–82.
23. O'Callaghan J, Mohan HM, Sharrock A, Gokani V, Fitzgerald JE, Williams AP, et al. A cross-sectional study of the financial cost of training to the surgical trainee in the UK and Ireland. *BMJ Open* 2017 Nov 15;**7**(11):e018086.
24. Gernsbacher MA. Video captions benefit everyone. *Policy Insights Behav Brain Sci* 2015 Oct;**2**(1):195–202.
25. Dinscore A, Andres A. Surgical videos online: a survey of prominent sources and future trends. *Med Ref Serv Q* 2010 Jan;**29**(1):10–27.
26. Celentano V, Browning M, Hitchins C, Giglio MC, Coleman MG. Training value of laparoscopic colorectal videos on the World Wide Web: a pilot study on the educational quality of laparoscopic right hemicolectomy videos. *Surg Endosc* 2017 Nov;**31**(11):4496–504.
27. Celentano V, Smart N, McGrath J, Cahill RA, Spinelli A, Obermair A, et al. LAP-VEGaS practice guidelines for reporting of educational videos in laparoscopic surgery: a joint trainers and trainees consensus statement. *Ann Surg* 2018 Mar 5. https://doi.org/10.1097/SLA.0000000000002725 [Epub ahead of print].
28. Mackenzie H, Ni M, Miskovic D, Motson RW, Gudgeon M, Khan Z, et al. Clinical validity of consultant technical skills assessment in the English national training programme for laparoscopic colorectal surgery. *Br J Surg* 2015 Jul;**102**(8):991–7.
29. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Acad Med* 2004;**79**(Suppl):S70–81.
30. Nisar PJ, Scott HJ. Key attributes of a modern surgical trainer: perspectives from consultants and trainees in the United Kingdom. *J Surg Educ* 2001;**68**(3):202–8.
31. Rolfe I, McPherson J. Formative assessment: how am I doing? *Lancet* 1995;**345**(8953):837–9.
32. Meyerson SL, Tong BC, Balderson SS, D'Amico TA, Phillips JD, De Camp MM, et al. Needs assessment for an errors-based curriculum on thoracoscopic lobectomy. *Ann Thorac Surg* 2012;**94**:368–73.
33. Steele SR, Arshad S, Bush R, Dasani S, Cologne K, Bleier JI, et al. Society of University Surgeons' Social and Legislative Committee. Social media is a necessary component of surgery practice. *Surgery* 2015;**158**:857–62.
34. Myers CG, Kudsi OY, Ghaferi AA. Social media as a platform for surgical learning: use and engagement patterns among robotic surgeons. *Ann Surg* 2017 Aug 29. https://doi.org/10.1097/SLA.0000000000002479.
35. Logghe HJ, Boeck MA, Atallah SB. Decoding Twitter: understanding the history, instruments, and techniques for success. *Ann Surg* 2016;**264**:904–8.
36. McGowen BS, Wasko M, Vartabedian BS, Miller RS, Freiherr DD, Abdolrasulnia M, et al. Understanding the factors that influence the adoption and meaningful use of social media by physicians to share medical information. *J Med Internet Res* 2012;**14**:e117.
37. Hennessy CM, Kirkpatrick E, Smith CF, Border S. Social media and anatomy education: using Twitter to enhance the student learning experience in anatomy. *Anat Sci Educ* 2016;**9**:505–15.
38. Groves T. Tweeting and rule breaking at conferences. *BMJ* 2016;**353**:i355.
39. Jacob BP, International Hernia Collaboration. *Facebook*. 2012. Available at: www.facebook.com/groups/herniacollab/.
40. Kudsi OY, Robotic Surgery Collaboration. *Facebook*. 2015. Available at: www.facebook.com/groups/1522777931338325/.
41. Hull L, Arora S, Aggarwal R, Darzi A, Vincent C, Sevdalis N. The impact of nontechnical skills on technical performance in surgery: a systematic review. *J Am Coll Surg* 2012;**214**(2):214–30.
42. Sevdalis N, Davis R, Koutantji M, Undre S, Darzi A, Vincent CA. Reliability of a revised NOTECHS scale for use in surgical teams. *Am J Surg* 2008;**196**(2):184–90.

Please cite this article in press as: Celentano V, et al., Use of laparoscopic videos amongst surgical trainees in the United Kingdom, The Surgeon (2018), https://doi.org/10.1016/j.surge.2018.10.004

Publication n. 9

Celentano, V., Coleman, M.G. (2016). Laparoscopic extended right hemicolectomy for hepatic flexure cancer: radical primary vascular approach - a video vignette. *Colorectal Disease* (2016) Jan;18(1):110-1.

laparoscopy. One of these was a B cell lymphoma and the other a carcinoid tumour, neither of which had been diagnosed by preoperative CT imaging. Two other patients had acute right-sided colonic volvulus, one of whom was untwisted by single-port laparoscopy and then had a laparoscopic-assisted right hemicolectomy while the other needed early conversion to a midline laparotomy. The remaining two patients (one shown in the associated video) had mesenteric ischaemia resulting in localized ileal infarction that was resected extracorporeally and re-anastomosed in one case.

We present this concept in the associated video and look forward to any comment from your readers.

F. Narouz*, H. Hadi Nahar Al Furajii†‡ and R. A. Cahill*†‡

*Departments of General and Colorectal Surgery, Beaumont Hospital, Dublin, Ireland; †Department of Surgery, Mater Misericordiae University Hospital, Dublin, Ireland and ‡Section of Surgery and Surgical Sciences, School of Medicine, University College Dublin, Dublin, Ireland
E-mail: ronan.cahill@ucd.com

Received 3 August 2015; accepted 17 August 2015; Accepted Article online 15 October 2015

References

1 Fung AK, Aly EH. Systematic review of single-incision laparoscopic colonic surgery. *Br J Surg* 2012; **99:** 1353–64.
2 Hompes R, Lindsey I, Jones OM *et al.* Step-wise integration of single-port laparoscopic surgery into routine colorectal surgical practice by use of a surgical glove port. *Tech Coloproctol* 2011; **15:** 165–71.
3 Cahill RA, Hompes R, Cunningham C, Mortensen NJ. Sealed orifice laparoscopic or endoscopic (SOLE) surgery: technology and technique convergence for next-step colorectal surgery. *Colorectal Dis* 2011; **13(Suppl 7):** 3–7.

Supporting Information

The video may be found in the online version of this article and also on the Colorectal Disease Journal YouTube and Vimeo channels:

Video S1. Operative video detailing the performance of single port laparoscopy in a patient suspected of having ischaemic bowel.

Laparoscopic extended right hemicolectomy for hepatic flexure cancer: a radical primary vascular approach with video vignette

doi:10.1111/codi.13156

Dear Sir,

We present a laparoscopic approach for extended right hemicolectomy using a four-trocar technique in a female patient aged 81 years with a hepatic flexure cancer.

Extended right hemicolectomy is a challenging laparoscopic procedure, and adequate surgical technique is essential to minimize cancer recurrence. Our principles are to respect the embryological plane between the mesocolon and the prerenal fascia with true central vascular ligation which maximizes the extent of lymphadenectomy.

The aim of this didactic video is to demonstrate our preferred technique for laparoscopic extended right hemicolectomy with a primary vascular approach and radical lymphadenectomy. The video concentrates on the key vascular steps needed to perform a radical lymphadenectomy safely, demonstrating a medial to lateral dissection of the right retrocolic space along Toldt's fascia, identification and high division of the ileocolic pedicle and dissection of the duodenum and the pancreas with high ligation of the right branch of the middle colic vessels. According to the principles of the 'no touch' technique the right colon is only mobilized laterally after the vascular supply has been interrupted, which also facilitates retraction during the medial dissection.

Many authors advocate true central vascular ligation of the middle colic vessels for tumours at the hepatic flexure [1], the rationale behind this being the reported variations of the vascular anatomy [2]. As the middle colic artery represents the main supply to the splenic flexure in about a third of individuals [3], a less extended procedure was preferred in this elderly patient preserving the left branch of the middle colic artery taking into account the impact of a potential subtotal colectomy.

V. Celentano and M. G. Coleman

Colorectal Unit, Derriford Hospital, Plymouth Hospitals NHS Trust, Plymouth, UK
E-mail: valeriocelentano@yahoo.it

Received 31 July 2015; accepted 20 August 2015; Accepted Article online 15 October 2015

References

1 Hohenberger W, Weber K, Matzel K, Papadopoulos T, Merkel S. Standardized surgery for colonic cancer: complete mesocolic excision and central ligation - technical notes and outcome. *Colorectal Dis* 2009; **11:** 354–64; discussion 364–5.

2 Nesgaard JM, Stimec BV, Bakka AO, Edwin B, Ignjatovic D, RCC study group. Navigating the mesentery: a comparative pre- and per-operative visualization of the vascular anatomy. *Colorectal Dis* 2015; **17:** 810–18.

3 Griffiths JD. Surgical anatomy of the blood supply of the distal colon. *Ann R Coll Surg Engl* 1956; **19:** 241–56.

Supporting Information

The video may be found in the online version of this article and also on the Colorectal Disease Journal YouTube and Vimeo channels:

Video S1. Laparoscopic extended right hemicolectomy for hepatic flexure cancer: a radical primary vascular approach.

Publication n. 10

Celentano, V., Smart, N., McGrath, J., Cahill, R.A., Spinelli, A., Obermair, A., Hasegawa, H., Lal, P., Almoudaris, A.M., Hitchins, C.R., Pellino, G., Browning, M.G., Ishida, T., Luvisetto, F., Cingiloglu, P., Gash, K., Harries, R., Harji, D., Di Candido, F., Cassinotti, E., McDermott, F.D., Berry, J.E.A., Battersby, N.J., Platt, E., Campain, N.J., Keeler, B.D., Boni, L., Gupta, S., Griffith, J.P., Acheson, A.G., Cecil, T.D., Coleman, M.G. (2018). LAP-VEGaS practice guidelines for reporting of educational videos in laparoscopic surgery: a joint trainers and trainees consensus statement. *Ann Surg*. 2018 Dec;268(6):920-926.

LAP-VEGaS Practice Guidelines for Reporting of Educational Videos in Laparoscopic Surgery

A Joint Trainers and Trainees Consensus Statement

Valerio Celentano, MD, FRCS,[,†] Neil Smart, PhD, FRCSEd,[‡] John McGrath, MD, FRCS,[§,¶] Ronan A. Cahill, MD, FRCS,[||,**] Antonino Spinelli, MD, PhD, FASCRS,[††,‡‡] Andreas Obermair, MD, FRANZCOG, CGO,[§§,¶¶] Hirotoshi Hasegawa, MD, PhD, FACS, FRCS,[||||] Pawanindra Lal, MS, FRCSEd, FRCSGlasg, FRCSEng, FACS, FAMS,[***,†††] Alex M. Almoudaris, PhD, FRCS,[‡‡‡,§§§] Charlotte R. Hitchins, BMBS, MRCS,[¶¶¶] Gianluca Pellino, MD,[|||||] Matthew G. Browning, MRCS,[¶¶¶] Takashi Ishida, MD,[||||] Federico Luvisetto, MD,[*] Pinar Cingiloglu, MBBS, DRANZCOG,[§§,¶¶] Katherine Gash, MBChB, MD,[****,††††] Rhiannon Harries, MRCS,[‡‡‡‡] Deena Harji, MBChB,[§§§§,¶¶¶¶] Francesca Di Candido, MD,[‡‡] Elisa Cassinotti, MD,[|||||||] Frank D. McDermott, MD, FRCS,[‡] James E. A. Berry, MD, FRCS,[¶¶¶] Nick J. Battersby, MRCS,[*****] Esther Platt, MRCS,[¶¶¶] Nicholas J. Campain, MRCS,[‡] Barrie D. Keeler, PhD FRCS,[†††††] Luigi Boni, MD, FACS,[|||||||,‡‡‡‡‡] Sharmila Gupta, MD, FRCS,[‡‡‡] John P. Griffith, FRCS,[§§§§§] Austin G. Acheson, MD, FRCS,[¶¶¶¶¶] Tom D. Cecil, DM, FRCS,[|||||||||] and Mark G. Coleman, MD, honFRCPSG, FRCS[¶¶¶,******]*

Objective: Consensus statement by an international multispecialty trainers and trainees expert committee on guidelines for reporting of educational videos in laparoscopic surgery.

Summary of Background Data: Instructive laparoscopy videos with appropriate exposition could be ideal for initial training in laparoscopic surgery, but there are no guidelines for video annotation or procedural educational and safety evaluation.

Methods: Delphi questionnaire of 45 statements prepared by a steering group and voted on over 2 rounds by committee members using an electronic survey tool. Committee selection design included representative surgical training experts worldwide across different laparoscopic specialties, including general surgery, lower and upper gastrointestinal surgery, gynecology and urology, and a proportion of aligned surgical trainees.

Results: All 33 committee members completed both the first and the second round of the Delphi questionnaire related to 7 major domains: Video Introduction/Authors' information; Patient Details; Procedure Description; Procedure Outcome; Associated Educational Content; Peer Review; and Use in Educational Curriculae. The 17 statements that did not reach at least 80% agreement after the first round were revised and returned into the second round. The committee consensus approved 37 statements to at least an 82% agreement.

Conclusion: Consensus guidelines on how to report laparoscopic surgery videos for educational purposes have been developed. We anticipate that following our guidelines could help to improve video quality.

These reporting guidelines may be useful as a standard for reviewing videos submitted for publication or conference presentation.

From the *Department of Colorectal Surgery. Queen Alexandra Hospital, Portsmouth Hospitals NHS Trust, Portsmouth, UK; †University of Portsmouth, Portsmouth, UK; ‡Exeter Health Services, Research Unit, Royal Devon & Exeter Hospital, Exeter, UK; §Department of Urology, Royal Devon and Exeter NHS Trust, Exeter, UK; ¶University of Exeter Medical School, Exeter, UK; ||Colorectal Unit, Mater Misericordiae University Hospital, Dublin, Ireland; **Section of Surgery and Surgical Specialities, School of Medicine, University College Dublin, Dublin, Ireland; ††Department of Biomedical Sciences, Humanitas University, Rozzano (Milano), Italy; ‡‡Colon and Rectal Surgery Unit, Humanitas Clinical and Research Center, Rozzano (Milano), Italy; §§Queensland Centre for Gynaecological Cancer, Royal Brisbane and Womens Hospital, Brisbane, Queensland, Australia; ¶¶The University of Queensland, Faculty of Medicine, UQCCR, Herston, Brisbane, Queensland, Australia; ||||Department of Surgery, School of Medicine, Keyo University, Tokyo, Japan; ***Division of Minimal Access Surgery, Department of Surgery, Maulana Azad Medical College, University of Delhi, New Delhi, Delhi, India; †††Lok Nayak Hospital, New Delhi, Delhi, India; ‡‡‡Department of Colorectal Surgery. Colchester Hospital NHS Foundation Trust, Colchester, UK; §§§Department of Surgery and Cancer, Faculty of Medicine, Imperial College London, St Mary's Hospital, London, UK; ¶¶¶Department of Colorectal Surgery, Plymouth Hospitals NHS Trust, Plymouth, UK; |||||Department of Medical, Surgical, Neurologic, Metabolic and Ageing Sciencies, Luigi Vanvitelli University, Naples, Italy; ****Department of Colorectal Surgery, Royal United Hospitals Bath, Bath, UK; ††††University of Bristol, Bristol, UK; ‡‡‡‡Wales Deanery Higher Surgical Training Programme, Wales, UK; §§§§Northern Deanery, Newcastle Upon Tyne, UK; ¶¶¶¶Clinical Trials Research Unit, University of Leeds, Leeds, UK; |||||||Department of General and Emergency Surgery - IRCCS -Fondazione Ca' Granda - Policlinico Hospital, Milan, Italy; *****Pelican Cancer Foundation, Basingstoke, UK; †††††School of Clinical Sciences, University of Nottingham, Nottingham, UK; ‡‡‡‡‡University of Milan, Milan, Italy; §§§§§Colorectal Unit, Bradford Teaching Hospitals NHS Foundation Trust, Bradford, UK; ¶¶¶¶¶National Institute for Health Research (NIHR) Nottingham Biomedical Research Centre, Nottingham University Hospitals NHS Trust and University of Nottingham, Nottingham, UK; |||||||||Peritoneal Malignancy Institute, Basingstoke, UK; and ******Plymouth University Peninsula School of Medicine & Dentistry, Plymouth, UK.

No industry input into guidelines development occurred, and no industry representatives were present at any of the meetings. No member of the guidelines committee received honoraria for any role in the guidelines process. The process relied solely on personal disclosure. All authors declare no conflict on interests and no funding has been received for the preparation of the study.

Reprints: Valerio Celentano, MD, FRCS, Consultant Colorectal Surgeon - Portsmouth Hospitals NHS Trust, Honorary Senior Lecturer – University of Portsmouth, Portsmouth, PO6 3LY UK. E-mail: valeriocelentano@yahoo.it.

ISSN: 0003-4932/16/XXXX-0001
DOI: 10.1097/SLA.0000000000002725

Keywords: distance learning, laparoscopic surgery video, laparoscopic video guidelines, surgical training, consensus guidelines

(*Ann Surg* 2018;xx:xxx–xxx)

AIM

This is a consensus statement by an international multispecialty joint trainers and trainees expert committee on guidelines for reporting of educational videos in laparoscopic surgery. It aims to provide consensus advice on how to report a surgical video for educational purposes.

The performance of advanced laparoscopic procedures requires dedicated surgical skills[1] to overcome specific technical difficulties.[2] Recent challenges in surgical education require new learning tools to try and overcome the time constraints.[3,4] The proportion of operations undertaken by surgical trainees has reduced in the past decade,[5] as they spend less time in theater and more time covering nights and acute admissions[6] and it has become obvious that the learning curve must be assisted by learning outside of the surgical theater. Audiovisual presentations are recognized in the medical field as important educational materials and they can be used to communicate information effectively to clinicians, patients, and students.[7,8]

Laparoscopic surgery lends itself to the production of audiovisual educational materials. The video recording of the procedure shows exactly what the surgeon is viewing providing surgical trainees with essential information regarding anatomy and the different steps of the operation. Uploading videos and sharing information on open access media broadcasting channels requires minimal technical skills and is now widely used by individuals and organizations who wish to reach out to the global audience and share information about scientific issues.[9] Recent studies suggest that these sources hold promise as educational tools for scientific disciplines,[10] but the trustworthiness of a large proportion of publicly available files remains questionable, as not all videos are authoritative and may not show techniques based on solid evidence. They may contain incorrect or misleading promotional information.[11,12] Instructive laparoscopy videos with appropriate exposition could therefore be ideal for initial training in laparoscopic surgery,[13] but unfortunately, there are no guidelines for annotating these videos or agreed methods to measure the educational content and the safety of the procedure presented.

On the basis of these premises, a pilot study on the educational quality of laparoscopic colorectal surgery videos highlighted the need for a standardized approach for reporting of educational videos in laparoscopic colorectal surgery.[14] In fact, the majority of videos available on the internet were found to be deficient in many aspects in order to be considered as an educational tool. Examples included lack of information on patients' data such as age, body mass index (BMI), history of previous surgery, indication for surgery, and surgical outcomes such as morbidity and histopathological assessment. Moreover, a survey among surgical trainees showed that in order to be useful as an educational tool, a laparoscopic video should be integrated with diagrams, snapshots, tables, and audio-commentary.

This pilot study has now led on to the development of a consensus statement on how to report a laparoscopic surgery video for educational purposes (LAP-VEGaS: LAParoscopic surgery Video Educational GuidelineS) in order to achieve high-quality educational videos that could improve surgical training.

METHODS

The scope of this guideline focused on educational value of laparoscopic surgical videos and surgical trainees were included as both curators and recipients of educational surgical videos. The guideline was developed in accordance with The Appraisal of Guidelines Research and Evaluation Instrument II (Agree II, http://www.agreetrust.org/agree-ii). An international consensus committee was selected and tasked with the development of guidelines on educational videos reporting in laparoscopic surgery. Committee selection was designed to include 15 participants representative of worldwide surgical trainers across different specialties, including general surgery, lower and upper gastrointestinal surgery, gynecology, and urology.

Every expert had the opportunity to indicate up to 2 surgical trainees with an interest in laparoscopic surgery to be included in the guidelines committee. In total therefore, 33 international members made up the joint trainers and trainees consensus statement panel.

A steering subcommittee consisting of 15 representatives from 8 countries and 5 surgical specialties developed the consensus statements. Topic selection was the responsibility of the steering committee and statements were finalized by discussion through e-mails, teleconferences, and face-to-face meetings. These statements were reviewed by the entire consensus committee and based on the results of the discussion; the steering committee prepared a Delphi questionnaire of 45 statements, which were voted on by the members using an electronic survey tool (Enalyzer, Denmark, www.enalyzer.com).

The Delphi method is a widely accepted technique for reaching a consensus among a panel of experts.[15] The experts respond anonymously to at least 2 rounds of a questionnaire; individuals voting against a statement are asked to provide a revised statement and/or explanation for their vote.[16] An a priori threshold of $\geq$80% affirmative votes was required for acceptance. Feedback on the statements that did not reach 80% agreement was reviewed by the steering committee after the first round and statements were revised and resubmitted for voting. After the recommendation statements were agreed upon, they were distributed to all the committee members to help engage all parties in the discussion. The draft manuscript was distributed for feedback to all guidelines members.

RESULTS

All 33 committee members completed both the first and the second round of the Delphi questionnaire. A vote was initially taken on 45 statements. The 17 statements that did not reach at least 80% agreement after the first round were revised and sent out for a second round of voting. Five of the original statements were consolidated into 2 statements after revision by the steering subcommittee. The committee approved 37 consensus statements, which are presented in 7 categories with the percentage of agreement summarized in Table 1. The statements that did not reach consensus agreement are presented in Table 2.

Author's Information and Video Introduction

S1. The video must include authors' information such as names, Institution(s), country, year of surgery. Contact details of the corresponding author must be provided.

S2. It should be specified if the video was presented at national/international meetings or recorded during a live broadcast.

S3. The title of the video must include the name of the procedure performed and of the pathology treated.

S4. If the video is intended for training, this should be specified and specific learning objectives could be presented. Aim of the video and relevance of the case presented should be stated.

S5. In case the procedure is performed by a surgical trainee, it should be mentioned how many previous cases the trainee has performed in order to contextualize the video.

S6. Patient consent should be obtained.

S7. A conflict of interest disclosure must be present.

TABLE 1. Thirty-seven Consensus Statements Approved by the Committee, with Rate of Agreement Among Committee Members

	Authors Information and Video Introduction	% Agreement
1	The video must include authors' information such as names, Institution(s), country, year of surgery. Contact details of the corresponding author must be provided.	88.4%
2	It should be specified if the video was presented at national/international meetings or recorded during a live broadcast.	81%
3	The title of the video must include the name of the procedure performed and of the pathology treated.	92.3%
4	If the video is intended for training this should be specified and specific learning objectives could be presented. Aim of the video and relevance of the case presented should be stated.	96.4%
5	In case the procedure is performed by a surgical trainee it should be mentioned how many previous cases the trainee has performed in order to contextualize the video.	89.2%
6	Patient consent should be obtained.	96.1%
7	A conflict of interest disclosure must be present.	92.3%
	Case presentation	
8	All radiology pictures, videos, and reports should be anonymized and the name of the patient should never be mentioned. All patient recognizable body parts such as eyes and tattoos should be obscured.	100%
9	The video should include one or more slides or audio-commentary with formal presentation of the case, including age, sex, American society of Anaesthesiologist score (ASA), body mass index (BMI), indication for surgery, comorbidities, and history of previous surgery.	92.3%
10	Results of preoperative imaging should be presented.	85.7%
11	Preoperative treatments, workup for surgery and blood test results should also be briefly presented if relevant for the case.	81%
	Demonstration of the surgical procedure	
12	The position of the patient on the operating table must be clearly demonstrated, including variations during the surgery.	96.1%
13	The position of the surgical and anesthetic team should be demonstrated, including scrub nurse position and position of extra assistants.	84.6%
14	The position of the trocars must be detailed. It should be mentioned where additional trocars can be inserted in case of unexpected findings or technical difficulties.	92.3%
15	The site for specimen extraction should be demonstrated.	88.4%
16	Details of special equipment needed for the procedure should be provided, such as vessel sealer devices, wound protectors, manipulators and surgical staplers.	88.4%
17	The surgical procedure should be presented in a standardized step by step fashion.	100%
18	Every chapter should be clearly introduced and explained. The intraoperative findings need to be demonstrated, with constant reference to the anatomy.	96.1%
19	Additional maneuvers and suggestions to face "progression failure" should be demonstrated – for instance additional ports or assistants, change of the position of the patient or rescue maneuvers in case of unexpected events such surgical stapler malfunction or equipment failure.	80.7%
20	Relevant additional intraoperative investigations should be mentioned and demonstrated.	96.4%
21	Describing the criteria for conversion to open surgery and the site of the incision in case of conversion might be useful in training videos.	100%
22	The open part of the procedure should be mentioned or demonstrated if the video is intended for training.	92.8%
	Outcomes of the procedure	
23	Outcomes of the procedure must be presented, including operating time, blood loss, cosmesis with picture of the healed wounds, length of hospital stay, and postoperative morbidity.	84.6%
24	Histopathology assessment of the specimen should be presented. In case of malignancy number of retrieved lymph nodes and TNM staging should be detailed. Pictures of the specimen are desirable.	92.8%
	Associated educational content	
25	Additional educational content must be included. Diagrams, photos, snapshots and tables should be used to demonstrate anatomical landmarks, relevant or unexpected findings.	84.6%
26	Audio/written commentary in English language must be provided	92.3%
	Peer review of surgical videos	
27	Educational videos must undergo formal peer review before publication. It should be stated if the video has been peer reviewed before publication.	96.1%
28	Peer review should assess not only the safety of the procedure performed, but also the supplementary educational content presented.	92.3%
29	Peer review should be undertaken by both surgical trainers and trainees.	81%
30	Videos should be amended and resubmitted, where possible, according to the reviewers' comments with a point by point answer.	96.4%
31	Image quality should be assessed. When excessive smoke, low definition, or suboptimal views are present for more than 25% of the duration of the procedure, the video should be rejected for poor image quality.	84%
32	Video should play at 1x speed. Where video is played faster or slower, the speed should be indicated in the respective video segments (eg, 2x, 4x, 0.5x).	100%
	Use of surgical videos in educational curriculae	
33	Routine video-recording of the procedure and review with feedback sessions should be mandatory in every training program.	84%
34	Video recording can be useful for continuous professional development even at the completion of the learning curve, in order to review unusual findings and to reflect on complications and outcomes.	96%
35	Videos demonstrating unusual cases and management of intraoperative complications should be shared at conferences.	100%
36	Formative assessment of the surgical performance should involve peer-review of unedited videos, using standardized assessment tools.	96%
37	The web platform should record the number of times the video has been watched for audit purposes. Moreover, it should allow comments and webchats in order to facilitate feedback and interaction amongst trainers and trainees.	92%

TABLE 2. Statements that did not Receive Consensus Agreement

	Rejected Statements	% Agreement
1	Anesthetic technique used for the procedure should be detailed with attention to pain relief and loco-regional blocks, insertion of nasogastric tube and urinary catheter, and deep vein thrombosis prophylaxis.	53.8%
2	It should be referenced how many procedures the authors perform, and brief summary of the outcomes, with mention to the expected learning curve to achieve proficiency with the procedure.	42.3%
3	Follow up duration, and follow-up pathways should be detailed.	50%
4	A comparison with other studies should be presented as an accessory slide.	34.6%
5	Essential references should be provided.	50%

Case Presentation

S8. All radiology pictures, videos, and reports should be anonymized and the name of the patient should never be mentioned. All patient recognizable body parts such as eyes and tattoos should be obscured.

S9. The video should include one or more slides or audio-commentary with formal presentation of the case, including age, sex, American society of Anaesthesiologist score (ASA), BMI, indication for surgery, comorbidities, and history of previous surgery.

S10. Results of preoperative imaging should be presented.

S11. Preoperative treatments, workup for surgery, and blood test results should also be briefly presented if relevant for the case.

Demonstration of the Surgical Procedure

S12. The position of the patient on the operating table must be clearly demonstrated, including variations during the surgery.

S13. The position of the surgical and anesthetic team should be demonstrated, including scrub nurse position and position of extra assistants.

S14. The position of the trocars must be detailed. It should be mentioned where additional trocars can be inserted in case of unexpected findings or technical difficulties.

S15. The site for specimen extraction should be demonstrated.

S16. Details of special equipment needed for the procedure should be provided, such as vessel sealer devices, wound protectors, manipulators, and surgical staplers.

S17. The surgical procedure should be presented in a standardized step-by-step fashion.

S18. Every chapter should be clearly introduced and explained. The intraoperative findings need to be demonstrated, with constant reference to the anatomy.

S19. Additional maneuvers and suggestions to face ‘‘progression failure’’ should be demonstrated – for instance, additional ports or assistants, change of the position of the patient, or rescue maneuvers in case of unexpected events such surgical stapler malfunction or equipment failure.

S20. Relevant additional intraoperative investigations should be mentioned and demonstrated.

S21. Describing the criteria for conversion to open surgery and the site of the incision in case of conversion might be useful in training videos.

S22. The open part of the procedure should be mentioned or demonstrated if the video is intended for training.

Outcomes of the Procedure

S23. Outcomes of the procedure must be presented, including operating time, blood loss, cosmesis with picture of the healed wounds, length of hospital stay, and postoperative morbidity.

S24. Histopathology assessment of the specimen should be presented. In case of malignancy, number of retrieved lymph nodes and TNM staging should be detailed. Pictures of the specimen are desirable.

Associated Educational Content

S25. Additional educational content must be included. Diagrams, photos, snapshots, and tables should be used to demonstrate anatomical landmarks, relevant, or unexpected findings.

S26. Audio/written commentary in English language must be provided.

Peer Review of Surgical Videos

S27. Educational videos must undergo formal peer review before publication. It should be stated if the video has been peer reviewed before publication.

S28. Peer review should assess not only the safety of the procedure performed but also the supplementary educational content presented.

S29. Peer review should be undertaken by both surgical trainers and trainees.

S30. Videos should be amended and resubmitted, where possible, according to the reviewers’ comments with a point by point answer.

S31. Image quality should be assessed. When excessive smoke, low definition or suboptimal views are present for more than 25% of the duration of the procedure, the video should be rejected for poor image quality.

S32. Video should play at 1x speed. Where video is played faster or slower, the speed should be indicated in the respective video segments (eg, 2x, 4x, 0.5x).

Use of Surgical Videos in Educational Curriculae

S33. Routine video-recording of the procedure and review with feedback sessions should be mandatory in every training program.

S34. Video recording can be useful for continue professional development even at the completion of the learning curve, in order to review unusual findings and to reflect on complications and outcomes.

S35. Videos demonstrating unusual cases and management of intraoperative complications should be shared at conferences.

S36. Formative assessment of the surgical performance should involve peer-review of unedited videos, using standardized assessment tools.

S37. The web platform should record the number of times the video has been watched for audit purposes. Moreover, it should allow comments and webchats in order to facilitate feedback and interaction among trainers and trainees.

DISCUSSION

High-quality research studies must generate transparent and reproducible research outputs, as complete and accurate reporting of original research is essential for health care professionals to translate research outcomes appropriately into clinical practice. Reporting guidelines, usually in the form of a checklist, flow diagram, or explicit text, specify a minimum set of information needed for a

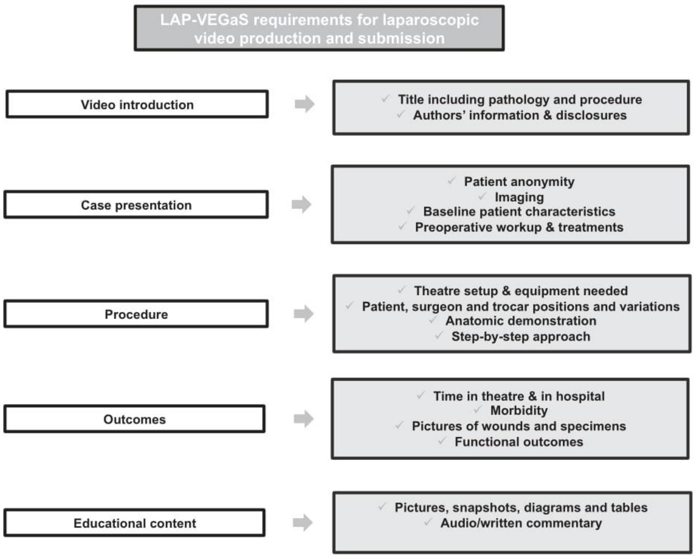


FIGURE 1. LAP-Vegas (LAParoscopic surgery Video Educational GuidelineS) essential requirements checklist for laparoscopic surgery video preparation and submission.

complete and clear account of what was done and what was found during a research study reflecting, in particular, aspects that might introduce bias into the research.[17] There is no equivalent set of reporting guideline for the presentation of surgical videos and, as such, the quality, reliability and educational rigor of these materials is highly variable. To improve the educational value of video outputs, especially if intended for training, the logical progression is to set a reference standard by introducing consensus-led guidance. In this study, an international, multispecialty, joint trainers-trainees committee developed consensus guidelines on how to report a laparoscopic surgery video for educational purposes. An essential requirements checklist for laparoscopic surgery video preparation and submission is proposed in Fig. 1.

Outcome-based assessment and competency-based curricula are learner-centered approaches that focus on the needs of the trainee[18] in whom monitoring of progression is an essential component requiring regular structured assessment.[19] Preoperative mental coaching leads to improved performance[20,21] and surgical trainees could ''warm up'' before surgery watching a video showing a step-by-step approach to the surgical procedure they are about to perform.[22] Expertise is not only related exclusively to volume of experience alone, but also relates to time spent practising with constructive feedback[23] and effective debriefing.[24] Structured evaluation emphasizes a learner-centered approach with specialty-[25,26] and procedure-specific[27] assessment tools of operative performance that are also applicable to video-based learning, having been developed. Consistent review of surgical videos could facilitate understanding of common errors in order to create awareness of potential injury mechanisms by acknowledging error-event patterns[28] and by engaging with online content through informal interactions[29] including peer discussion facilitated via social media, which can provide an important component of surgeons' ongoing development by shared experiential learning and knowledge.[30]

The LAP-VEGaS guidelines presented here aim to improve the educational quality of laparoscopic videos available to surgical trainees and have been specifically developed as a joint trainers and trainees project, valuing the need for additional educational content when the video is intended for training. Additional items that can ease understanding of the procedure that should be made available to trainees include the use of snapshots and diagrams to facilitate the recognition of anatomy and the division of the procedure into different steps.[14] Photographic documentation of key steps of the procedure can be used for audit purposes to acknowledge the safety of the procedure performed,[31] while written commentary, diagrams, and snapshots are particularly beneficial for people watching videos in their non-native language.[32] The name of the procedure performed and the nature of the pathology should be specified in the title to facilitate retrieval of the video in view of the constantly increasing number of published laparoscopic videos every year.[14] It is important to reinforce that patient's authorization to reproduce and disseminate the video is mandatory and identifying details should be removed. Authors must also disclose conflict of interest, especially when the procedure is performed with dedicated equipment.[33]

The LAP-VEGaS joint trainers-trainees committee acknowledge that intraoperative and postoperative outcomes are of paramount importance to understand the effectiveness of the procedure. Nevertheless, it is expected that videos demonstrating an uncomplicated procedure are more likely to be found online, resulting in a publication bias[34] the same way that manuscripts with a positive result are more likely to be submitted and subsequently published than inconclusive or negative studies, as researchers are often reluctant to submit a report when the results are not statistically significant.[35] A formal peer-review process is recommended before publication of the video. Constructive criticism based on these guidelines could ensure the credibility of the source and the safety of the procedure presented, with an expected resultant improvement in the quality of the educational videos available on the World Wide Web. Controversially, the number of videos undergoing peer-review before publication is decreasing, raising concerns over safety of the educational content provided.[14] This likely reflects the constraints on achieving a timely peer review,[36] which could be facilitated by following these guidelines. An additional limitation of these guidelines is that they do not apply to all educational surgical videos, for instance basic skills training or videos demonstrating a single step of a procedure, which may not need the extensive clinical detail, but simply basic details such as the author identification and video introduction. Lack of multimedia resources at some institutions is unlikely to prevent the production of high-quality videos, as current endoscopy systems are equipped with video-recording devices, which make it easy to capture high-quality images in a digital format and to produce instructive videos even with minimal prior video editing experience.[37] Although addition of extra material and chaptering adds some technical nuance, many video editing programs are now available at no or low-cost and the added value should justify the added effort.

Live surgical demonstrations are becoming increasingly popular and considered to be useful as an effective source of continuing medical education.[38] Nevertheless, despite their potential educational benefits, significant concerns about patient safety and clinical integrity remain[39] with operating surgeons reporting high levels of anxiety when performing live-demonstrations, which increased further when these took place at a foreign institution or in an unfamiliar environment.[40,41] Patients should be made fully aware of the implications and potential risks associated with live surgery broadcasts,[42] as performing live complex laparoscopic procedures puts additional pressure on the surgeon and could expose the patient to increased risk.

Reporting guidelines are facilitators of good research and their use is indirectly influencing the quality of future research, as being open about the study shortcomings when reporting one study can influence the conduct of the next study. We propose that following guidelines could similarly help improve video quality and additionally may offer a standardized tool for use in assessing video quality in materials submitted for publication or conferences, although we acknowledge that they were not formulated with this intended purpose and future validation studies would be required.

CONCLUSION

In the absence of robust primary evidence, the LAP-VEGaS consensus guidelines on how to report laparoscopic surgery videos for educational purposes have been developed utilizing the Delphi methodology. We propose that adherence to the guidelines described could help improve the educational value of video materials when used for the purposes of training. These reporting guidelines may also have utility as a tool to assess the overall video quality when reviewing material submitted for publication or conferences, although further validation studies would be required.

REFERENCES

1. Kim J, Edwards E, Bowne W, et al. Medial-to-lateral laparoscopic colon resection: a view beyond the learning curve. *Surg Endosc*. 2007;21:1503–1507.
2. Scott DJ, Young WN, Tesfay ST, et al. Laparoscopic skills training. *Am J Surg*. 2001;182:137–142.
3. Stein S, Stulberg J, Champagne B. Learning laparoscopic colectomy during colorectal residency: what does it take and how are we doing? *Surg Endosc*. 2012;26:488–492.
4. Celentano V, Finch D, Forster L, et al. Safety of supervised trainee performed laparoscopic surgery for inflammatory bowel disease. *Int J Colorectal Dis*. 2015;30:639–644.
5. Greensmith M, Cho J, Hargest R. Changes in surgical training opportunities in Britain and South Africa. *Int J Surg*. 2016;25:76–81.
6. Bell RH, Biester TW, Tabuenca A, et al. Operative experience of residents in US general surgery programs: a gap between expectation and experience. *Ann Surg*. 2009;249:719–724.
7. Ozyurda F, Dökmeci F, Palaoğlu O, et al. The role of interactive training skills courses in medical education at the Ankara University School of Medicine. Teach Learn Med 2002; 14:189–193.
8. McEwen A, Moorthy C, Quantock C, et al. The effect of videotaped preoperative information on parental anxiety during anesthesia induction for elective pediatric procedures. *Paediatr Anaesth*. 2007;17:534–539.
9. Dinscore A, Andres A. Surgical videos online: a survey of prominent sources and future trends. *Med Ref Serv Q*. 2010;29:10–27.
10. Jaffar AA. YouTube: an emerging tool in anatomy education. *Anat Sci Educ*. 2012;5:158–164.
11. Singh AG, Singh S, Singh PP. YouTube for information on rheumatoid arthritis–a wakeup call? *J Rheumatol*. 2012;39:899–903.
12. Duncan I, Yarwood-Ross L, Haigh C. YouTube as a source of clinical skills education. *Nurse Educ Today*. 2013;33:1576–1580.
13. Hall JC. Imagery practice and the development of surgical skills. *Am J Surg*. 2002;184:465–470.
14. Celentano V, Browning M, Hitchins C, et al. Training value of laparoscopic colorectal videos on the World Wide Web: a pilot study on the educational quality of laparoscopic right hemicolectomy videos. *Surg Endosc*. 2017;31:4496–4504.
15. Linstone HA, Turoff M. *The Delphi Method Techniques and Applications*. Reading, PA: Addison-Wesley Publishing Company; 1975.
16. Varela-Ruiz M, Díaz-Bravo L, García-Durán R. Description and uses of the Delphi method for research in the healthcare area. *Inv Ed Med*. 2012;1:90–95.
17. Larson EL, Cortazal M. Publication guidelines need widespread adoption. *J Clin Epidemiol*. 2012;65:239–246.
18. Long DM. Competency-based residency training: the next advance in graduate medical education. *Acad Med*. 2000;75:1178–2118.
19. van der Vleuten CP, Schuwirth LW. Assessing professional competence: from methods to programmes. *Med Educ*. 2005;39:309–317.
20. Arora S, Aggarwal R, Sevdalis N, et al. Development and validation of mental practice as a training strategy for laparoscopic surgery. *Surg Endosc*. 2010;24:179–870.
21. Rogers RG. Mental practice and acquisition of motor skills: examples from sports training and surgical education. *Obstet Gynecol Clin North Am*. 2006;33:297–304. ix.
22. Louridas M, Bonrath EM, Sinclair DA, et al. Randomized clinical trial to evaluate mental practice in enhancing advanced laparoscopicsurgical performance. *Br J Surg*. 2015;102:37–44.
23. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Acad Med*. 2004;79(Suppl):S70–S81.
24. Arora S, Ahmed M, Paige J, et al. Objective structured assessment of debriefing: bringing science to the art of debriefing in surgery. *Ann Surg*. 2012;256:982–988.
25. Champagne BJ, Steele SR, Hendren SK, et al. The American Society of Colon and Rectal Surgeons assessment tool for performance of laparoscopic colectomy. *Dis Colon Rectum*. 2017;60:738–744.
26. Miskovic D, Wyles SM, Carter F, et al. Development, validation and implementation of a monitoring tool for training in laparoscopic colorectal surgery in the English National Training Program. *Surg Endosc*. 2011;25:1136–1142.
27. Goderstad JM, Sandvik L, Fosse E, et al. Assessment of surgical competence: development and validation of rating scales used for laparoscopic supracervical hysterectomy. *J Surg Educ*. 2016;73:600–608.
28. Meyerson SL, Tong BC, Balderson SS, et al. Needs assessment for an errors-based curriculum on thoracoscopic lobectomy. *Ann Thorac Surg*. 2012;94:368–373.
29. Steele SR, Arshad S, Bush R, et al. Society of University Surgeons' Social and Legislative Committee. Social media is a necessary component of surgery practice. *Surgery*. 2015;158:857–862.
30. Myers CG, Kudsi OY, Ghaferi AA. Social media as a platform for surgical learning: use and engagement patterns among robotic surgeons. *Ann Surg*. 2018;267:233–235.
31. Lam T, Usatoff V, Chan ST. Are we getting the critical view? A prospective study of photographic documentation during laparoscopic cholecystectomy. *HPB (Oxford)*. 2014;16:859–863.
32. Gernsbacher MA. Video captions benefit everyone. *Policy Insights Behav Brain Sci*. 2015;2:195–202.
33. Patel SV, Yu D, Elsolh B, et al. Assessment of conflicts of interest in robotic surgical studies: validating author's declarations with the open payments database. *Ann Surg*. 2017 [Epub ahead of print].
34. Mahid SS, Qadan M, Hornung CA, et al. Assessment of publication bias for the surgeon scientist. *Br J Surg*. 2008;95:943–949.

35. Dickersin K, Min YI, Meinert CL. Factors influencing publication of research results. Follow-up of applications submitted to two institutional review boards. *JAMA*. 1992;267:374–378.
36. Stahel PF, Moore EE. Peer review for biomedical publications: we can improve the system. *BMC Med*. 2014;12:179.
37. Menashe S, Otjen J, Thapa MM. Techniques for creating video content for radiology education. *Radiographics*. 2014;34:1819–1823.
38. Mullins JK, Borofsky MS, Allaf ME, et al. Live robotic surgery: are outcomes compromised? *Urology*. 2012;80:602–607.
39. Kallmes DF, Cloft HJ, Molyneux A, et al. Live case demonstrations: patient safety, ethics, consent, and conflicts. *Lancet*. 2011;377:1539–1541.
40. Khan SA, Chang RT, Ahmed K, et al. Live surgical education: a perspective from the surgeons who perform it. *BJU Int*. 2014;114:151–158.
41. Duty B, Okhunov Z, Friedlander J, et al. Live surgical demonstrations: an old, but increasingly controversial practice. *Urology*. 2012;79:e7–e11.
42. Challacombe B, Weston R, Coughlin G, et al. Live surgical demonstrations in urology: valuable educational tool or putting patients at risk? *BJU Int*. 2010;106:1571–1574.

Publication n. 11

Celentano, V., Flashman, K. (2019). Stepwise training in laparoscopic surgery for complex ileocolonic Crohn's disease: analysis of 127 training episodes. *J Surg Educ*. 2019 Sep-Oct;76(5):1364-1369

Stepwise Training in Laparoscopic Surgery for Complex Ileocolonic Crohn's Disease: Analysis of 127 Training Episodes

Valerio Celentano, MD, FRCS,[*,†] *and Karen G. Flashman, BSc*[*]

[*]Colorectal Unit, Queen Alexandra Hospital – Portsmouth Hospitals NHS Trust, Portsmouth, United Kingdom; and [†]University of Portsmouth, Portsmouth, United Kingdom

INTRODUCTION: The inflammation encountered in Crohn's disease makes a minimally invasive approach challenging due to a thickened mesentery, fistulas, abscesses, and large phlegmons with high reported rates of conversion and septic complications. Aim of this study was to evaluate the feasibility of a stepwise approach to training in laparoscopic surgery for complex Crohn's disease.

METHODS: Every surgical procedure was divided in 4 different training tasks: access and exposure, bowel mobilization, division of the mesentery, anastomosis. Extensive adhesiolysis and division and repair of fistulae were considered as additional tasks when present. The laparoscopic competence assessment tool was used to evaluate the safety and proficiency of the surgical performance. The primary outcome was the rate of training tasks successfully completed by surgical trainees.

RESULTS: One hundred and twenty seven training episodes were included and 86 were performed by trainees (67.7%). Fistula division was the less commonly performed training task (25%), while mobilisation and anastomosis were performed by the supervised trainee in 90% and 85% of the cases. Safety and proficiency scores were significantly higher for senior trainees compared to junior trainees.

CONCLUSIONS: Laparoscopic surgery for complex Crohn's disease can be safely performed in a supervised setting with acceptable operating time, postoperative length of hospital stay, and 30 day morbidity. (J Surg Ed 000:1−6. © 2019 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

Reprints: Reprints will not be available from the authors.

Correspondence: Inquiries to Valerio Celentano MD, FRCS, Colorectal Unit, Queen Alexandra Hospital – Portsmouth Hospitals NHS Trust, Portsmouth, United Kingdom; e-mail: valeriocelentano@yahoo.it

KEY WORDS: Colorectal surgery, Crohn's disease, Laparoscopy, Surgical training, Inflammtory bowel disease

COMPETENCIES: Patient Care, Medical Knowledge, Practice-Based Learning and Improvement, Patient Centered Care

INTRODUCTION

The advent of laparoscopic surgery has dramatically changed the landscape of colorectal surgery for both benign and malignant disease. Laparoscopy offers well-described benefits[1] such as decreased pain, lower wound complication rates, improved pulmonary function, earlier resumption of diet and bowel function, better cosmesis and shorter hospital stay[2] when compared to open surgery.

However, widespread use of laparoscopy in Crohn's disease (CD) has been more limited due to technical constraints: the inflammation encountered in CD is often multifocal and makes a minimally invasive approach challenging due to a thickened mesentery, as well as the potential for fistulas, abscesses, and large phlegmons[3-4]; moreover, the lack of tactile feedback potentially limits the identification of occult disease.[5] High conversion rates have been reported in surgery for penetrating and recurrent CD with abscesses and adhesions representing the main reasons for conversion.[6] Relatively high rates of morbidity and septic complications have been reported in patients who undergo resections for CD, with reported rates of intra-abdominal sepsis and anastomotic leak as high as 14% and 17% respectively.[7] These challenges explain the concerns on feasibility and safety of training in laparoscopic surgery for complex CD and aim of this study was to evaluate the feasibility of a stepwise approach to training in laparoscopic surgery for complex CD.

  1931-7204/$30.00 https://doi.org/10.1016/j.jsurg.2019.03.009

METHODS

Study Settings

All patients undergoing laparoscopic surgery for penetrating or recurrent ileocolonic CD from January 2017 to December 2018 were included in this prospective observational study. Patients undergoing open, single-incision, robotic or hand-assisted surgery were excluded as were patients undergoing emergency operations. The indication for surgical resection was discussed at a dedicated inflammatory bowel disease multidisciplinary team meeting involving gastroenterologists, colorectal surgeons, radiologists, and pathologists. Preoperative assessment included colonoscopy, magnetic resonance imaging enterography, and intestinal ultrasound.

Stepwise Training Evaluation

In our unit, which had been one of the major contributing centres for the national laparoscopic surgery training program in Great Britain[8] the ileocolic resection is performed according to a standardized technique,[9] with extracorporeal division of the small bowel mesentery and anastomosis.

For the purposes of this study every surgical procedure was divided in 4 different training tasks: access and exposure, bowel mobilisation, division of the mesentery, anastomosis. Extensive adhesiolysis, strictureplasties and division and repair of sigmoid and bladder fistulae were considered as additional tasks when present.[10] All procedures were video-recorded and it was annotated which tasks of the procedure were performed by the surgical trainee, considering as trainee-completed tasks with minimal active help from the trainer and mainly led by the surgical trainee with the trainer assisting and supervising.[11] All surgeries were performed under direct supervision of a consultant surgeon specialized in inflammatory bowel disease surgery, present and scrubbed in theatre during the entire case.

After completion of a 2-year postgraduate Foundation programme, the UK surgical training pathway is structured with a 2-year "Core Surgical Training" programme, followed by 6-year "Specialist Training" programme.[12] Only procedures performed by trainees currently enrolled in the Specialist Training programme were included in the study and trainees in the first 3 years of the programme were defined as "junior trainees", while trainees in the final 3 years of the programme were defined as "senior trainees". Procedures performed by surgical fellows undertaking an additional training period at the end of their formal training were added to the senior trainees group.

In order to assess the safety and proficiency of the trainees' surgical performance a validated competency assessment tool specifically designed for laparoscopic colorectal surgery was used.[13] The laparoscopic competency assessment tool (LCAT) is a task-specific marking sheet for the assessment of technical surgical skills in laparoscopic colorectal surgery (Table 1). It is designed to assess the surgeon's performance by watching a live, live-streamed or recorded operation. The procedure is divided into 4 different tasks: each task has 4 different items which are scored based on the safety and effectiveness of the procedure. The overall mean score for each case ranges from 1 to 4, and the pass mark was set at 2.7 as validated in a previous study.[14] This pass mark was the score above which expert assessors rated the operations as "safe performance", defined by receiver operating characteristic curve analysis. Extensive adhesiolysis, strictureplasties, and division and repair of sigmoid and bladder fistulae were considered as additional tasks when present and in order to obtain scores comparable to the LCAT marking sheet, every step of these additional tasks was ranked from 1 to 4 (hazardous, imprecise, safe, and efficient) with regards to bowel manipulation, use of graspers, use of dissection tools, and suturing/anastomosis. The evaluation of the trainees' performance was undertaken during the theatre de-briefing in a face-to-face session between the trainer and the trainee and only the tasks performed by the trainee were assessed.

Data Collection

Preoperative, operative, and postoperative data were prospectively recorded for each patient. Preoperative

TABLE 1. Laparoscopic Competence Assessment Tool (LCAT)

Task Step 1 "Exposure"	Operating ports insertion and complete exposure of the operating field to commence dissection. Low scores are assigned in case of forceful and potentially dangerous port insertion as for ineffective grasping of the bowel and mesentery and exposure of the operative field.
Task Step 2 "Vascular pedicle"	Starts with the retraction of the vascular pedicle and ends with the complete division of the mesocolon, focusing on the assessment of appropriate level of section of the vascular pedicle and avoiding blind application of clips/stapler.
Task Step 3: "Mobilization"	Includes the separation of tissue planes with full mobilisation of the bowel for resection. The procedure is scored against the adequacy of tissue planes maintained and length of mobilized bowel.
Task Step 4: "Resection/anastomosis"	Complete dissection of the bowel and the creation of the anastomosis.

parameters included age, sex, body mass index, comorbidities, American Society of Anaesthesiologists status, albumin and haemoglobin concentration, previous abdominal surgery, smoking status, weight loss, indication for surgery, and preoperative medical therapy.

Operative data included duration of surgery, intraoperative complications, estimated operative blood loss, reasons for conversion and use of temporary ileostomy. Postoperative data included postoperative length of hospital stay, time to tolerate oral fluids and oral diet, time to resolution of ileus and postoperative complications according to the Dindo−Clavien classification.[15]

Study Objectives

The primary outcome was the rate of training tasks successfully completed by surgical trainees. Secondary outcomes were operating time and safety of the procedure according to the LCAT scores.

Statistical Analysis

Categorical variables are presented as frequency or percentage and were compared with the use of the chi-square test or Fisher's exact test, as appropriate. Continuous variables are presented as mean (±standard deviation) or median (range) and were compared with the use of Student's *t* test. The Mann−Whitney *U* test was used for continuous, not normally distributed outcomes. Statistical analysis was performed by using the Statistical Package for Social Sciences (SPSS version 16.0; SPSS, Chicago, IL). All reported p values were two-tailed, and p values of less than 0.05 were considered to indicate statistical significance.

Ethics

The study is conducted in accordance with the principles of the Declaration of Helsinki and "good clinical practice" guidelines. Informed consent has been obtained from the patients.

RESULTS

One hundred and twenty-seven training episodes were included and 86 were performed by trainees (67.7%). 48 tasks (37.8%) involved penetrating CD with fistula formation, while the remaining 79 included redo surgery for recurrent CD (62.2%). Junior trainees only performed 41 of the 72 tasks they were involved in (56.9%), while senior trainees performed 46 out of 55 tasks (83.6%) $p < 0.0001$.

Fistula division was the less commonly performed training episode (25%), while mobilisation and anastomosis were performed by the supervised trainee in 90% and 85% of the cases. The adhesiolysis was performed by trainees in 67% of the cases, while access and exposure in 52%. LCAT scores were significantly higher for senior trainees compared to junior trainees, with a mean score of 3.4 and 2.5 respectively ($p < 0.0001$). In none of the included patients all the steps of the procedure were performed entirely by the trainer.

Data on individual tasks operating time was retrospectively retrieved from the video analysis. No differences were found in the median operating time needed for individual tasks completion amongst the tasks performed by the trainer and the junior and senior trainees (34.1 ± 27.6, 28.4 ± 25.8, 32.7 ± 30.1 minutes respectively), which could be explained by the different complexity of the tasks performed.

Postoperative outcomes are presented in Table 2; there were 4 readmissions and 1 reoperation for washout of intra-abdominal haematoma.

DISCUSSION

Despite the benefits of laparoscopic surgery,[16] a considerable number of CD patients may be a formidable challenge even for the most experienced laparoscopic surgeon,[17] who also has to be prepared to deal with unexpected findings that may require additional surgery, such as proximal strictures, fistulas, abscesses, or phlegmons, which can be identified in about 20% of patients.[18] Surgery for CD is technically challenging and the perioperative decision making of when to operate and whether to fashion an anastomosis or to create a stoma, require highly trained surgeons.[19] Despite this, our study found that up to 83% of these operations can be safely performed in a supervised setting when the surgery is performed by a senior surgical trainee, with postoperative outcomes such as operating time, length of hospital stay and 30-day morbidity comparable with the data reported in the literature. More junior trainees may benefit from exposure to these

TABLE 2. Patients Characteristics and Surgical Outcomes

Number of patients	27
Age (years)	39.3 ± 14.2
Sex (M:F)	11:16
BMI	24.6 ± 5.3
ASA	
− I	6
− II	18
− III	3
Conversion to open	1 (3.7%)
Ileostomy	1 (3.7%)
Operating time (minutes)	156.2 ± 39.4
Blood Loss (ml)	68.4 ± 52.9
LOS (days)	6 (2-35)
Readmissions	4 (14.8%)
Reoperations	1 (3.7%)
Overall 30 day morbidity	5 (18.5%)

LOS: length of hospital stay.

procedures; however they are less likely to perform some of the most difficult training tasks such as division and repair of fistulising disease. In order to maximise training opportunities colorectal surgery training units should aim to allocate trainees with appropriate level of prior exposure to these complex laparoscopic CD cases. We used the LCAT, an objective assessment tool, to critically appraise the performance of the surgical trainees across the different training episodes. Given that feedback has been demonstrated to improve performance,[20] this should be a fundamental part of training in advanced laparoscopic surgery, despite it being a shift from the more traditional method of surgical teaching.[21] Technical competency is dependent on supervised training volume,[13] which is consistent with the theory of deliberate practice, indicating that expertise is not related exclusively to the volume of experience but to time spent practising with constructive feedback.[22] Therefore, technical competence should be based on objective assessment of the quality of performance rather than solely relying on the number of procedures performed. In our unit we encourage video-based review of the trainees' own performance and this study highlights the advantages of advocating routine video-recording of the surgical procedure which can then be reviewed with peers and trainers.[23] The LCAT score may also be valuable in assessing over a period of time the proficiency gain of the same cohort of surgical trainees indicating the appropriate timing for exposure to more complex surgeries. Feedback on the training episode is ideally delivered at the end of the training session in a face-to-face debriefing, but we must acknowledge that this happens only in 41% of the theatre lists, according to a recent survey of UK trainees,[24] with time constrictions probably accounting as the main limiting factor.[25] The time needed for constructive feedback and structured LCAT assessment has not been directly measured as a study end-point, mainly due to the trainer/assessor being scrubbed in theatre for the whole procedure. Median operating time of 152 minutes represents a surrogate of video length for review and assessment; however, further studies are needed to explore the role of e-feedback for procedural skills acquisition in surgery.[26]

Increased rates of adverse clinical outcomes at the early stage of the learning curve raise ethical questions and highlight the need for mechanisms to reduce complications and conversions during the initial stage of independent practice. A number of studies have reported on the length of the learning curve for laparoscopic colorectal resections by using different methods and end-points resulting in suggested numbers between 11 and 110 cases.[27] This heterogeneity is easily explained by the different parameters used for evaluating the learning curve such as conversion rate, operating time, blood loss, and rate of postoperative complications.[28] The average length of the proficiency gain curve in laparoscopic colorectal surgery for self-taught senior surgeons is estimated between 100 and 150 procedures.[29] Supervised training programs have demonstrated to significantly decrease the length of the learning curve,[30] and an autodidactic approach to acquire the necessary skills for laparoscopic surgery should be considered obsolete and unacceptable.

The patients' population of this study is heavily selected, potentially resulting in the trainers performing the most complex cases and taking over procedures that were too difficult for the trainees. It is important to consider that patient safety must never be compromised; therefore, it is hard to imagine a surgeon watching a trainee getting into trouble without intervening. The presence in theatre or at the operating table of the trainer makes obviously a significant difference, and this is what we exactly aim in a laparoscopic training unit. It is important to consider that also the trainees' population of this study is heavily selected, as only procedures involving trainees enrolled in a higher surgical training programme were included. The validity of our results may be specific to the UK training programme and stratifying the different experience of the trainees accordingly to previously performed procedures rather than seniority would have resulted in more robust data.

CONCLUSIONS

A stepwise training approach can be applied to laparoscopic surgery for complex Crohn's disease with a high rate of tasks successfully performed by supervised trainees and an acceptable profile of postoperative outcomes.

REFERENCES

1. Holubar SD, Dozois EJ, Privitera A, et al. Laparoscopic surgery for recurrent ileocolic Crohn's disease. *Inflamm Bowel Dis*. 2010;16:1382–1386.
2. Tan JJ, Tjandra JJ. Laparoscopic surgery for Crohn's disease: a meta-analysis. *Dis Colon Rectum*. 2007;50:576–585.
3. Lesperance K, Martin MJ, Lehmann R, Brounts L, Steele SR. National trends and outcomes for the surgical therapy of ileocolonic Crohn's disease: a population-based analysis of laparoscopic vs. open approaches. *J Gastrointest Surg*. 2009;13:1251–1259.
4. Marcello PW. Laparoscopy for inflammatory bowel disease: pushing the envelope. *Clin Colon Rectal Surg*. 2006;19:26–32.
5. Celentano V, Finch D, Forster L, Robinson JM, Griffith JP. Safety of supervised trainee-performed

laparoscopic surgery for inflammatory bowel disease. *Int J Colorectal Dis*. 2015;30:639–644.

6. Pinto RA, Shawki S, Narita K, Weiss EG, Wexner SD. Laparoscopy for recurrent Crohn's disease: how do the results compare with the results for primary Crohn's disease? *Colorectal Dis*. 2011;13:302–307.

7. Yamamoto T, Allan RN, Keighley MR. Risk factors for intra abdominal sepsis after surgery in Crohn's disease. *Dis Colon Rectum*. 2000;43:1141–1145.

8. Coleman M, Rockall T. Teaching of laparoscopic surgery colorectal. The LAPCO model. *Cir Esp*. 2013;91:279–280.

9. Celentano V. Laparoscopic redo surgery in recurrent ileocolic Crohn's disease: a standardised technique. *J Minim Access Surg*. 2018 Sep 3. https://doi.org/10.4103/jmas.JMAS_144_18. [Epub ahead of print].

10. Celentano V. Decision making in primary Crohn's enteritis complicated by ileosigmoid fistula: laparoscopic approach – a video vignette. *Colorectal Dis*. 2018 Jul;20:642.

11. George BC, Teitelbaum EN, Meyerson SL, et al. Reliability, validity, and feasibility of the Zwisch scale for the assessment of intraoperative performance. *J Surg Educ*. 2014 Nov-Dec;71:e90–e96.

12. Writing group; Project steering group; ASiT/BOTA Lost Tribe Study Group. Early years postgraduate surgical training programmes in the UK are failing to meet national quality standards: an analysis from the ASiT/BOTA Lost Tribe prospective cohort study of 2,569 surgical trainees. *Int J Surg*. 2017 Oct 14. https://doi.org/10.1016/j.ijsu.2017.09.074. pii: S1743-9191(17)31327-4 [Epub ahead of print].

13. Mackenzie H, Ni M, Miskovic D, et al. Clinical validity of consultant technical skills assessment in the English National Training Programme for Laparoscopic Colorectal Surgery. *Br J Surg*. 2015;102:991–997.

14. Miskovic D, Ni M, Wyles SM, et al. Is competency assessment at the specialist level achievable? A study for the national training programme in laparoscopic colorectal surgery in England. *Ann Surg*. 2013;257:476–482.

15. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240:205–213.

16. Dunker MS, Stiggelbout AM, van Hogezand RA, Ringers J, Griffioen G, Bemelman WA. Cosmesis and body image after laparoscopic-assisted and open ileocolic resection for Crohn's disease. *Surg Endosc*. 1998;12:1334–1340.

17. Celentano V, Sagias F, Flashman KG, Conti J, Khan J. Laparoscopic redo ileocolic resection for Crohn's disease in patients with previous multiple laparotomies. *Scand J Surg*. 2018 May 1:1457496918772370. https://doi.org/10.1177/1457496918772370. [Epub ahead of print].

18. Duepree HJ, Senagore AJ, Delaney CP, Brady KM, Fazio VW. Advantages of laparoscopic resection for ileocecal Crohn's disease. *Dis Colon Rectum*. 2002;45:605–610.

19. Morar PS, Hollingshead J, Bemelman W, et al. Establishing key performance indicators [KPIs] and their importance for the surgical management of inflammatory bowel disease-results from a Pan-European, Delphi Consensus Study. *J Crohns Colitis*. 2017 Oct 27;11:1362–1368.

20. Nisar PJ, Scott HJ. Key attributes of a modern surgical trainer: perspectives from consultants and trainees in the United kingdom. *J Surg Educ*. 2001;68:202–208.

21. Rolfe I, McPherson J. Formative assessment: how am I doing? *Lancet*. 1995;345:837–839.

22. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Acad Med*. 2004;79 (Suppl):S70–S81.

23. Celentano V, Smart N, McGrath J, et al. LAP-VEGaS practice guidelines for reporting of educational videos in laparoscopic surgery: a joint trainers and trainees consensus statement. *Ann Surg*. 2018 Dec;268:920–926.

24. Celentano V, Smart N, Cahill RA, et al. Use of laparoscopic videos amongst surgical trainees in the United Kingdom. *Surgeon*. 2018 Nov 9. pii: S1479-666X(18)30123-9.

25. Keis O, Grab C, Schneider A, Öchsner W. Online or face-to-face instruction? A qualitative study on the electrocardiogram course at the University of Ulm to examine why students choose a particular format. *BMC Med Educ*. 2017 Nov 9;17:194.

26. Al-Jundi W, Elsharif M, Anderson M, Chan P, Beard J, Nawaz S. A randomized controlled trial to compare e-feedback versus "standard" face-to-face verbal feedback to improve the acquisition of procedural skill. *J Surg Educ*. 2017 May - Jun;74:390–397.

27. Tekkis PP, Senagore AJ, Delaney CP, et al. Evaluation of the learning curve in laparoscopic colorectal surgery: comparison of right-sided and left-sided resections. *Ann Surg*. 2005;242:83–91. 13.

28. Barrie J, Jayne DG, Wright J, et al. Attaining surgical competency and its implications in surgical clinical trial design: a systematic review of the learning curve in laparoscopic and robot-assisted laparoscopic colorectal cancer surgery. *Ann Surg Oncol*. 2014;21:829–840. 14.

29. Miskovic D, Ni M, Wyles SM, Tekkis PP, Hanna GB. Learning curve and case selection in laparoscopic colorectal surgery: systematic review and international multicenter analysis of 4852 cases. *Dis Colon Rectum*. 2012;55:1300–1310. 15.

30. Mackenzie H, Miskovic D, Ni M, et al. Clinical and educational proficiency gain of supervised laparoscopic colorectal surgical trainees. *Surg Endosc*. 2013;27:2704–2711.

SUPPLEMENTARY INFORMATION

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.jsurg.2019.03.009.

Appendix 2. Ethics review checklist

FORM UPR16

Research Ethics Review Checklist

Please include this completed form as an appendix to your thesis (see the Research Degrees Operational Handbook for more information

Postgraduate Research Student (PGRS) Information		**Student ID:**	950270
PGRS Name:	Valerio Celentano		
Department:	Faculty of Science and Health	**First Supervisor:**	Dr Mick Harper
Start Date: (or progression date for Prof Doc students)		**01/10/2019**	

Study Mode and Route:	Part-time	☒	MPhil	☐	MD	☐
	Full-time	☐	PhD	☒	Professional Doctorate	☐

Title of Thesis:	Video based learning in surgical education: a new modality for hybrid training in minimally invasive surgery.
Thesis Word Count: (excluding ancillary data)	8263

If you are unsure about any of the following, please contact the local representative on your Faculty Ethics Committee for advice. Please note that it is your responsibility to follow the University's Ethics Policy and any relevant University, academic or professional guidelines in the conduct of your study

Although the Ethics Committee may have given your study a favourable opinion, the final responsibility for the ethical conduct of this work lies with the researcher(s).

UKRIO Finished Research Checklist:
(If you would like to know more about the checklist, please see your Faculty or Departmental Ethics Committee rep or see the online version of the full checklist at: http://www.ukrio.org/what-we-do/code-of-practice-for-research/)

a) Have all of your research and findings been reported accurately, honestly and within a reasonable time frame?	YES NO	☒ ☐
b) Have all contributions to knowledge been acknowledged?	YES NO	☒ ☐
c) Have you complied with all agreements relating to intellectual property, publication and authorship?	YES NO	☒ ☐
d) Has your research data been retained in a secure and accessible form and will it remain so for the required duration?	YES NO	☒ ☐
e) Does your research comply with all legal, ethical, and contractual requirements?	YES NO	☒ ☐

Candidate Statement:

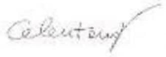
I have considered the ethical dimensions of the above named research project, and have successfully obtained the necessary ethical approval(s)

Ethical review number(s) from Faculty Ethics Committee (or from NRES/SCREC):	

If you have *not* submitted your work for ethical review, and/or you have answered 'No' to one or more of questions a) to e), please explain below why this is so:

This is a PhD by publication thesis, which is based on 11 previously published manuscripts.
All the included manuscripts were evaluated by the relevant Ethics committee, and approved, as required.
The thesis presents no new research or experiments and therefore no new Ethical approval was required.

UPR16 – April 2018

Signed *(PGRS)*:		**Date:** 10/09/2020