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MINIREVIEWS

Minimally invasive surgery for inflammatory bowel disease: Review of current developments and future perspectives

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Abstract

Patients with inflammatory bowel disease (IBD) comprise a population of patients that have a high likelihood of both surgical treatment at a young age and repetitive operative interventions. Therefore surgical procedures need to aim at minimizing operative trauma with best postoperative recovery. Minimally invasive techniques have been one of the major advancements in surgery in the last decades and are nowadays almost routinely performed in colorectal resections irrespective of underlying disease. However due to special disease related characteristics such as bowel stenosis, interenteric fistula, abscesses, malnutrition, repetitive surgeries, or immunosuppressive medications, patients with IBD represent a special cohort with specific needs for surgery. This review summarizes current evidence of minimally invasive surgery for patients with Crohn's disease or ulcerative colitis and gives an outlook on the future perspective of technical advances in this highly moving field with its latest developments in single port surgery, robotics and trans-anal techniques.

Key words: Inflammatory bowel disease; Minimally invasive surgery; Laparoscopy; Colorectal; Robotic

Core tip: Laparoscopic techniques have been applied to a wide variety of surgical procedures for inflammatory bowel disease (IBD). Beside the feasibility and safety, numerous short time advantages for laparoscopic techniques such as reduced trauma, reduction of morbidity, and reduced hospital stays have been well documented for IBD patients as well. Newly emerging minimally invasive techniques such as single port laparoscopic surgery, robotic surgery or transanal techniques will further expand the field of IBD surgery.

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INTRODUCTION

Medical treatment is still considered the first line approach for patients with inflammatory bowel disease (IBD)[1]. However despite novel therapeutic strategies, up to 80% of patients with Crohn's disease and 30% of patients with ulcerative colitis still require surgery during their course of disease[2,3]. The vast majority of patients will be operated at a fairly young age[4]. Furthermore, substantial numbers of patients especially with Crohn's disease might require repetitive surgery due to complications or disease recurrence. Therefore development of surgical techniques to minimize operative trauma has been of great interest. In fact minimally invasive surgery has been one of the recent major advances in surgery in the last decades[5].

In the following, current evidence for minimally invasive surgery for IBD will be discussed followed by an outline of possible future advances in this moving field.

Current status of minimally invasive surgery for IBD

For Crohn's disease as well as ulcerative colitis, development of minimally invasive techniques has evolved with more caution than in other colorectal diseases. This was mostly due to special disease related characteristics that are associated with IBD such as bowel inflammation with obliteration of surgical layers, complicated anatomy following multiple operations, potentially fistulizing disease or difficulties in anastomotic healing. But also the patient's impaired physical condition due to chronic inflammation, bowel obstruction, malnutrition, anemia, hypoalbuminemia, or the need for immunosuppressive medication such as steroids, azathioprine, or anti-TNF-α agents; doubts have been raised whether minimally invasive surgery is suitable for patients suffering from IBD. However, during the last decades, nearly all primary surgical procedures for IBD, varying from stricturoplasties, segmental resections, or proctocolectomies, were reported to having been performed safely in a laparoscopic fashion, even with substantial advantages as compared to conventional approaches in large clinical series and trials. Today minimally invasive surgery is broadly accepted as a safe surgical strategy in primary and complicated cases of Crohn's disease as well as restorative proctocolectomies for patients with ulcerative colitis[6-8]. This is also reflected by incorporation of laparoscopic approaches into several clinical guidelines by national and international medical societies on IBD[9,10]. Although most of the possible advantages of minimally invasive approaches like shorter hospital stay, less wound infections, and reduced pain are true for both entities of IBD, special clinical characteristics of the diseases require separate discussion (for an overview of the cited literature for the respective technical advancements see also Table 1).

Laparoscopic surgery for Crohn's disease

With ileocolic involvement being the most common disease pattern, ileocolic resections for refractory stricturing disease represent the main surgical treatment for patients with Crohn's disease. A large body of literature has been published comparing laparoscopic to open ileocolic resections with 2 randomized trials and 3 meta-analyzes representing the highest level of evidence[11-15]. Altogether the trials have shown comparable results with a trend towards faster recovery of bowel function, shorter hospital stay and fewer complications in the laparoscopic groups. However none of these reached statistical significance in the randomized trials, which might mostly be due to a comparably low number of included inpatients. Recently the patients of both randomized trials have been followed up for long term results and the studies have been published consecutively[16,17]. Altogether data suggested no differences between the different approaches in terms of recurrence of disease or long term morbidity, again being limited by a small number of included patients.

For recurrent disease following initial surgical resection acquisition of data is more complex due to complicated anatomy and the inhomogeneous presentation of disease. However, recently a growing amount of literature has been published on outcomes following laparoscopic and open approaches for recurrent disease[18,19]. Data has shown that a laparoscopic approach for recurrent disease seems safe with comparable outcomes to open surgery. However, whether a laparoscopic approach for recurrent disease irrespective of the initial approach is advantageous is still in debate. Most specifically it seems not clear yet, whether in case of recurrence the possible advantages of laparoscopic surgery can be maintained following midline laparotomy of the initial operation[20]. Another subject of debate is the feasibility of laparoscopic surgery for cases with disease related complications such as penetrating disease. Recently in a prospective study, Goyer *et al*[21] compared outcomes following laparoscopic or open surgery for ileocolic resection for penetrating or recurrent disease in 54 patients to non-complicated primary Crohn's disease in 70 cases. Overall penetrating disease was associated with a higher likelihood of conversions, higher number of diverting stoma being performed, and longer operative times compared to primary non-penetrating disease. However no difference was observed whether an open or laparoscopic approach was chosen. Recently in a nationwide data analysis in the United States, Lesperance *et al*[22] investigated the use and outcomes of laparoscopic surgery for patients with Crohn's disease. All patients from the Nationwide inpatient Sample database that have been operated between 2000 and 2004 were analyzed. A total number of 389911 patients received treatment because of Crohn's disease and 12% (n = 49609) required surgical treatment. Independent predictors for patients being operated laparoscopically were: Age below 35 years, female gender, admission to a teaching hospital, ileocecal disease and lower disease stage. Compared to open operations minimally invasive operations were associated with lower percentage

Table 1 Minimally Invasive techniques for inflammatory bowel diseases

Technical development		Indications[1]	Performed procedures	Advantages	Ref.
Laparoscopy/ laparoscopically assisted	UC	Elective surgery[1] Refractory disease[1] Malignancy	Proctocolectomy + IPAA	Reduced trauma Similar recovery Similar LOS Similar morbidity	[28,29,32,33]
		Urgent surgery[1] High immuno-suppression[1]	Subtotal colectomy	Reduced trauma Faster recovery Reduced LOS	[5,23-27,31]
	CD	Primary disease[1] Recurrent disease Complicated disease Stenosing disease[1] Penetrating disease Fistulizing disease	Ileo-/colonic resection	Reduced trauma Faster recovery Reduced LOS Less morbidity	[11-22]
HALS	UC	Elective surgery[1] Refractory disease[1] Malignancy Complex cases Learning curve of lap	Proctocolectomy + IPAA Subtotal colectomy	Reduced trauma Similar recovery Similar LOS Similar morbidity Reduced operative time compared to lap Possibly less conversions to open resections compared to lap	[30,34-37]
	CD	Fistulizing disease Elective surgery[1] Refractory disease[1] Malignancy Complex cases	Ileo-/colonic resection	Reduced trauma Similar recovery Similar LOS Similar morbidity Reduced operative time compared to lap Possibly less conversions to open resections compared to lap	[37]
SPLS	UC	(Elective refractory disease)	Proctocolectomy + IPAA[2]	Fewer number of incisions Comparable morbidity[2]	[41-43]
	CD	Elective[1] Stenosing disease[1] Recurrent disease[2] Disease related complications[2]	Ileo-/colonic resection	Shorter hospital stay compared to lap Reduced pain compared to lap Similar morbidity compared to lap	[38-40]
NOTES/NOSE	UC	-	Proctectomy	-	[54-57,59]
	CD	Perianal fistulizing disease Stenosing disease	Proctectomy Colectomy Ileocolic resections	Reduction of needed incisions for specimen removal	
Trans-anal minimally invasive surgery	UC	Elective surgery[1] Refractory disease[1] Malignancy	Transanal proctectomy for IPAA	Transanal removal of colon with performance of anastomosis	[59]
	CD	Perianal fistulizing disease Supraanal stenosis	Transanal completion proctectomy	Transanal removal of colon with performance of anastomosis/ perineal closure	[52,53,58]
Robotic surgery	UC/CD	Elective surgery[1] Refractory disease[1] Malignancy	Completion proctectomy following laparoscopic colectomy	Comparable postoperative morbitidy	[45-49]

[1]Indicates main indications for the respective procedure; lap = multitrocar laparoscopic surgery; [2]Indicates only limited evidence available. UC: Ulcerative colitis; CD: Crohn's disease; IPAA: Ileal pouch-anal anastomosis; HALS: Hand assisted laparoscopic surgery; SPLS: Single port laparoscopic surgery; NOSE: Natural orifice specimen extraction; TAMIS: Trans-anal minimally invasive surgery; LOS: Length of stay.

of complications, shorter length of stay, and reduced mortality. Open operations were more likely performed for patients in fistulizing disease and when an ostomy was necessary[22]. This indicates that there is still a need for conventional surgery in patients with Crohn's disease, especially for those with complicated disease and repetitive surgery. Patient selection is highly valuable for the surgeon's decision whether to perform an open or laparoscopic approach. However, for patients with primary stricturing ileocolic disease, a laparoscopic approach seems to be the method of choice today.

Laparoscopic surgery for ulcerative colitis

For ulcerative colitis the main indications for surgery are a refractory course of disease, risk of malignant transformation and emergency indications for severe colitis refractory to medical treatment. In case of emergency indications a subtotal colectomy without primary anastomoses is recommended[1]. The rationale behind this is to remove most of the diseased colon

while minimizing the risk of surgical complications such as anastomotic leakage. Whether a laparoscopic or open approach should be selected for subtotal colectomy in the emergency setting has been investigated by multiple studies[23-27]. Most of these show similar results for laparoscopic or open resection, some showing favorable results for laparoscopy concerning postoperative morbidity, return of bowel function and length of stay. On the down part laparoscopic surgery is associated with longer operative times. Taken together laparoscopy seems to be safe for cases of medical refractory severe colitis; however no study has yet shown feasibility of laparoscopic approaches for complications such as perforation or toxic megacolon[5]. Therefore "emergency surgery" should be interpreted as "urgent surgery" for refractory disease in studies as mentioned above, while critical bleeding or free perforations with four quadrant peritonitis still seem to be a domain of conventional surgery in ulcerative colitis.

In case of elective surgery for medically refractory disease, performance of an ileal J-pouch with ileal pouch anal anastomosis (IPAA) following proctocolectomy has become the method of choice. In the majority of cases the operation is performed as a two staged procedure with proctocolectomy and pouch formation under protection of a diverting loop-ileostomy in the first setting and stoma reversal in the second. With laparoscopy being more routinely performed today, literature about comparison of open to laparoscopic approaches has increased[28-30]. Results so far show similar outcomes in terms of intra-operative blood loss, postoperative morbidity, time to bowel function and length of hospital stay. In most studies different approaches of laparoscopic assisted operations have been compared to open resections. Mostly for laparoscopy a laparoscopic assisted approach is employed with addition of a Pfannenstiel-incision for specimen removal and pouch formation. Limitations of comparative studies so far might have been a potential selection bias within the different groups. Therefore Gu *et al*[31] have recently analyzed their outcomes of laparoscopic and open total colectomy, adjusted for possible confounders. They report that after statistical adjustments for covariates such as age, comorbidities, ASA score and others, patients with the laparoscopic approach still had favorable outcomes in terms of postoperative recovery. In a recent meta-analysis published by Singh *et al*[32], the authors investigated operative outcomes following laparoscopic *vs* open restorative proctocolectomy with functional results as primary outcome measures and intraoperative details, short term outcomes as well as adverse events as secondary end points. A total of 27 studies with 2428 patients were analyzed. Laparoscopic operations were performed in 45.1% of the operations and were associated with a shorter length of stay, less wound infections and reduced intraoperative blood loss. There were no differences in terms of pouch failure with a tendency of better pouch function following minimally invasive operations. Another prospective randomized controlled single center trial was performed by a German group in 2013 (LapConPouch-Trial)[33]. Blood loss was used as the primary endpoint, unfortunately the trial had to be stopped due to insufficient patient recruitment. However the results were published after a total of 21 patients were included in each group (laparoscopic *vs* open restorative proctocolectomy) with statistical analysis being performed exploratively. In their mixed population of patients with ulcerative colitis and familial adenomatous polyposis no differences in terms of blood loss were found. No differences were noted in secondary outcomes such as length of hospital stay, postoperative pain, bowel function and quality of life (QOL). The different technical strategies of laparoscopic or laparoscopic assisted restorative proctocolectomy respectively will be discussed below.

TECHNICAL DEVELOPMENTS AND FUTURE PERSPECTIVES

Hand assisted laparoscopic surgery

The idea of combining the benefits of minimally invasive surgery with the possibility of tactile feedback and manual assistance while performing complex colorectal resections has led to the development of the hand assisted laparoscopic approach. One of the first descriptions of the technique for colonic resections has been published by Bemelman *et al*[34] in 1996. They reported their initial experience in using a "pneumo-sleeve" to provide abdominal access of the surgeons hand while preserving pneumoperitoneum. For a limited number of five patients with mostly diverticular disease, they have shown feasibility of the approach that enables tactile feedback and hand assistance during laparoscopic resections. In 2004 Nakajima *et al*[35] published their experience of hand assisted laparoscopic surgery (HALS) colectomies compared to classic laparoscopic approaches. A total of 12 HALS resections (5 total proctocolectomies, 7 total abdominal colectomies) have been compared to 11 laparoscopic resections. Most significantly, total operative time could be reduced by almost 1 h using the HALS-technique. Total blood loss and length of incisions were similar in both groups since in the majority of the laparoscopic cases an additional Pfannenstiel-incision was used for specimen retrieval and usage of stapling devices. The authors concluded that even in centers with a high level of laparoscopic experience employment of HALS-ports can lead to further improvement of postoperative outcomes. Maartense *et al*[30] have compared HALS to open restorative proctocolectomy in a prospective randomized trial. A total number of 60 patients have been included. The authors have evaluated postoperative QOL as the primary end-point of the study and operating time, blood loss, conversion rates, morbidity, morphine requirement, mortality and costs as secondary end points. Operating time in the laparoscopic groups was significantly longer than in the

open group (214 min compared to 133 min, $P = 0.001$). In the minimally invasive group 5 patients had major complications with anastomotic leakages of IPAA in 2 patients compared to 4 patients of the open group. In the laparoscopic group revision surgery was performed laparoscopically while in the open group relaparotomy was performed. In the postoperative period no differences between the groups were recorded in terms of recovery, pain, morphine requirement and return to normal diet. Most interestingly, with regard to the primary endpoint, no differences in development of QOL measures were noted. In both groups QOL significantly dropped during the first 2 wk following surgery. This was irrespective of the type of surgery. Patients of both groups returned to baseline level after 4 wk and 3 mo after surgery patients had better QOL scores than before surgery. Altogether the study could not show any measurable advantage of the minimally invasive approach. The authors argue that probably the impact of the operation on the QOL outweighed the possible advantages of smaller incisions. However it has to be noted that in their analysis the main difference was only the colectomy part of the operation since the proctectomy was performed *via* a Pfannenstiel incision in the minimally invasive group and a midline incision in the open group. This might also explain the missing differences in terms of pain medication.

A Cochrane analysis from the Netherlands that included data from 11 trials with a total number of 607 patients of whom 253 (41%) have been operated using a laparoscopic approach showed no significant differences in terms of the main postoperative outcomes[36]. There was no significant difference concerning morbidity or mortality between the groups. Although until publication of the study only 1 randomized controlled trial has been performed and could be included in the analysis, over all outcomes of the studies show increasing safety of laparoscopic approaches for restorative proctocolectomies. With more and more evidence on the safety of laparoscopic resections and with advancing learning curves in minimally invasive colorectal surgery, many surgeons leave hand-assisted procedures in favor of full laparoscopic procedures, putting hand-assisted surgery in the background. In an interesting retrospective study Jadlowiec *et al*[37] investigated the technical evolution of laparoscopic colorectal resection within their tertiary center. Minimally invasive procedures for IBD showed steady growth with a higher number of pure laparoscopic operations, a decrease in the amount of HALS-procedures and a plateau in open resections. Altogether irrespective of the indication, although decreasing in total numbers, HALS-operations were still chosen for more complex cases - especially with possible advantages in case of present fistulizing disease. As the authors point out, HALS surgery has still a role as a learning instrument in the acquisition of surgical skills prior to performance of pure laparoscopic resections. With respect to conversion rates the possibility to perform HALS complimentary to laparoscopic resections might result in less conversions to open resections.

Single port laparoscopic surgery

Single port laparoscopic surgery (SPLS) was developed to further reduce the operative trauma through reduction of needed incisions to only one. Usually a paraumbilical or transumbilical incision is used for insertion of a single port for introduction of the camera as well as all working instruments.

Our group has recently reported our experience with single incision surgery for elective ileocolic resections in Crohn's disease[38]. In a match pair analysis 20 single incision ileocolic resections for stricturing ileocolic Crohn's disease were compared to 20 multi-trocar resections for the same indication. Altogether the results between the two approaches were comparable in terms of postoperative morbidity, postoperative pain and conversion rates (SPLS group 5%, laparoscopy group 10%). Another study that compared postoperative outcomes of single-trocar *vs* multi-trocar ileocecal resections was published in 2013[39]. Twenty one patients who had ileocolic resections using a single port approach were matched and compared to patients with ileocolic resections in a multitrocar approach. Matching criteria comprised BMI, length of diseased bowel resected and the presence of fistulizing disease. Comparison of the 21 single port patients had little but significantly shorter length of hospital stay and less morphine use on postoperative day 1. All other outcome measures such as postoperative pain and complications were similar in both groups. Taken the results of the 2 studies together, in this well-defined and elective setting of surgery for primary ileocolic disease, single port surgery was fully comparable to the multi-trocar approach, however long term results are still under investigation. Furthermore only a few studies have analyzed outcomes following single port surgery for complicated or recurrent Crohn's disease. To analyze the feasibility of single port laparoscopy in patients with complicated or recurrent disease, an Irish group has recently investigated their patients that presented either with urgent interventions ($n = 15$), prior abdominal interventions ($n = 8$), obstruction ($n = 7$), intraabdominal mass ($n = 6$), fistulizing disease ($n = 6$) or abscess ($n = 4$). For all indications the operation was initiated using a single port approach[40]. For introduction of the instruments a surgical glove port was used. In most cases ileocolonic resections were performed. Conversion rate was 15% and associated with the complexity of clinical presentation. Overall the authors conclude that even in patients with disease related complications or recurrent disease initial single port laparoscopy can be used with acceptable morbidity and conversion rates. Especially long term evaluation of the cosmetic results will be most interesting since reduction in incision length and avoidance of additional incisions is the biggest difference between the techniques, with claimed benefits in postoperative pain, adhesions, and cosmetic results for the single port

technique.

For ulcerative colitis, Geisler *et al*[41] reported their initial experience with single port proctocolectomy and ileal-pouch-anal-anastomosis. Although limited by a fairly low number of 5 patients with ulcerative colitis as well as familial adenomatous polyposis, they have shown technical feasibility of the method. In the following years SPLS proctocolectomy has also been investigated by other groups[42,43]. Gash *et al*[42] described a series of patients where restorative proctocolectomy was performed using a SPLS trocar through the existing or planed ileostomy site. In their analysis they reported no complications associated with the approach with good function of the pouch following ileostomy reversal. Consecutively Bulian *et al*[43] described the case of a patient who had previous subtotal colectomy and ileostomy for restorative proctocolectomy as a three staged approach. SPLS was used for formation of the pouch through the ostomy site and the rectal stump was resected and closed extra-abdominally. Pouch formation was performed outside the abdomen and the pouch-anal anastomosis was performed using the SPLS trocar without further incisions.

Altogether SPLS seems to be feasible and safe for elective colorectal resections for IBD. Nevertheless, the SPLS technique is elaborate and needs getting used to even for experienced laparoscopic surgeons. Therefore there is doubt if SPLS will get adapted by most surgeons in future. Moreover long term data is still missing and evidence is needed, whether the approach is suitable for different indications of complicated Crohn's disease. Additionally, yet no true advantages other than fewer numbers of incisions have been reported and it is still open whether these differences have a significant impact on the QOL of the patients.

Robotic surgery for IBD

Ongoing innovation in the field of robotic surgery and its progressing use in different surgical disciplines starting with urology and gynecology has now let to its increasing use in colorectal surgery. Pigazzi *et al*[44] published their initial experience with low rectal resections for rectal cancer using the da vinci robotic system. Literature published so far has shown feasibility of the robotic approach for performance of proctectomy in patients with rectal cancer. In 2012 Miller *et al*[45] published their short term results of robotic *vs* laparoscopic surgery for patients with IBD. In a case-matched study design they analyzed 17 robotic proctectomies following laparoscopic total abdominal colectomy. There were no conversions to open surgery and the results were comparable between the 2 groups. However at the beginning of the study the authors reported longer operation times, slower postoperative recovery and longer length of stay in the robotic group, but these differences equalized during the study period. Postoperative mortality, especially anastomotic leakage did not differ between the 2 groups. The study is certainly limited by a low number of patients and a retrospective design; however it has demonstrated a possible combination of laparoscopic and robotic surgery for proctocolectomy in patients with IBD. In the same year McLemore *et al*[46] published their initial results of a case series about robotic-assisted laparoscopic two-staged restorative proctectomy for toxic ulcerative colitis. In three cases with toxic ulcerative colitis that had previously undergone laparoscopic colectomy a robotic-assisted completion proctectomy with ileal-J-Pouch anastomosis was performed. These preliminary results have added to the combined experience of a robotic-assisted approach for completion proctectomy and pouch formation following laparoscopic colectomy. Possible advantages of robotic surgery are mostly expected in rectal resections because of the limited space in the lower rectum. Here usage of robotic assisted operations is believed to bring advantages in terms of nerve preserving operations with possibly better oncologic outcomes. However, robotic colorectal operations have also been used in locations other than the rectum. In a single case presentation Tou *et al*[47] have recently shown technical feasibility of robotic assisted performance of strictureplasty for refractory stenosis of the terminal ileum. Following laparoscopic exploration of the abdomen, the robot was successfully used for the incision as well as performance of a two layered anastomosis. Additionally Juo *et al*[48] have published their experience with robotic single incision colorectal resections for different indications. They reported on 31 right hemicolectomies, 20 sigmoid colectomies, 5 left hemicolectomies, 2 low anterior resections and 1 total colectomy. Although only 1 patient with IBD was included, the study has certainly shown technical feasibility of robotic assisted surgery in colorectal operations of different extensions. Especially the conversion rate to open procedures was comparably low (6.8%). Postoperative complications occurred in 27.1% of the cases. Five of those were classified severe complications, three moderate, and seven mild complications[48]. With more and more experience in colorectal robotic surgery, development to total robotic operations with performance of intraabdominal anastomoses has gained more attention. In a case series Lujan *et al*[49] published their experience with intracorporeal anastomoses following right hemicolectomy for a mixed cohort of indications. In their 58 operations, 52 anastomoses were performed intra-corporally with a complication rate of 19% and only 1 anastomotic leakage. Although an additional incision for extraction of the specimen was used, the study reports feasibility of the approach for different indications. However, long term data will be necessary to estimate the true impact of robotic assisted colorectal surgery for IBD. While robotic approaches in the low pelvis appear to be reasonable, robotic techniques in more than one abdominal quadrant as required for example for proctocolectomy for ulcerative colitis seem to be very elaborate with doubts concerning medical and economic benefits so far.

Natural orifice specimen extraction techniques for IBD

Avoidance of further incisions to extract the resected specimen is a further step towards fully laparoscopic operations. Without the need to remove the resected bowel through the abdominal wall, additional incisions such as a Pfannenstiel incision can be avoided. Not only for colon resections in patients with ulcerative colitis but also for ileocolic resections and colectomies in patients with Crohn's disease this method of specimen extraction is feasible[50,51]. Especially for patients with colectomy or proctectomy, extraction of the specimen through the rectum has been described in different studies[52,53]. For ileocolic resections, Eshuis *et al*[51] have reported that the specimen can be extracted by an intraoperative endoscopist before suturing of the anastomosis. In case of performance of ostomies, the specimen can also be extracted through the planned ostomy site. Limitations of these emerging techniques are technical difficulty, potentially longer operating times and possible difficulties with extraction of large specimen.

Transperineal completion proctectomy

Performance of completion proctectomy is considered the last option for refractory perianal fistulizing disease with rectal involvement. In the literature around 10%-20% of the patients with Crohn's disease will eventually require proctectomy[54,55]. As an alternative to a low Hartman procedure, where an anterior rectal resection is completed by stapling of the rectum at the dentate line, an interspincteric resection procedure has recently been described as the method of choice for completion proctectomy in patients with Crohn's disease[56]. The procedure can be performed *via* a transperineal approach and usage of ultrasonic dissection of the rectum. An advantage of the technique compared to a low Hartman situation is complete resection of rectal mucosa and thereby reduction of Crohn's associated symptoms. Furthermore, as the authors point out, close dissection of the rectum is preservation of the rectal mesentery with only a small residual cavity in the lesser pelvis. For patients with ulcerative colitis completion proctectomy is generally performed following subtotal colectomy with performance of terminal ileostomy without the possibility of reconstructive surgery. In these cases the remaining rectal stump is a potential source of residual inflammation and associated morbidity. Liyanage *et al*[57] have introduced an alternative approach for performance of completion proctectomy other than abdomino-perineal resection. Using an endoscopic microsurgery TEM-equipment the authors performed perineal proctectomy following abdominal subtotal colectomy for ulcerative colitis. Twelve patients have been included in their preliminary study. The operation was initiated by an intersphincteric dissection following insertion of the proctoscope and performance of close rectal dissection. The specimen was then extracted perineally and the external sphincter was closed using an absorbable suture. In four patients there was delayed healing in the perineal wound with no associated morbidity. Altogether the authors have illustrated that in their limited number of patients, employment of TEM instruments for performance of trans-anal intersphincteric dissection and completion proctectomy is feasible with acceptable outcomes.

Transanal reconstructive rectal surgery

One of the latest technical advances in colorectal surgery is the further development of trans-anal minimally invasive surgery. The main principle of transanal surgical approaches has already been developed decades ago and now has gained a revival in attention. The method has mostly been employed for local excisions of rectal neoplasia but lately has also been successfully expanded for treatment of other distal colorectal disease[58]. Basic principle of the technique is the idea of easy transanal entrance to the mesorectal plane for rectal excisions such as in total mesorectal excision (TME) in case of rectal cancer. For the transanal introduction of the instruments different port systems have been used, altogether they represent the base for the so called transanal minimally invasive surgery (TAMIS)-platform for the use of regular laparoscopic instruments. The technique has mostly been investigated for performance of TME with the idea of a nerve sparing approach in rectal cancer. In most cases TAMIS is combined with abdominal laparoscopic surgery for performance of proximal mobilization of the colon and rectum prior to transanal resection and performance of anastomosis. The latter is an important point which distinguishes transanal minimally invasive surgery from transanal completion proctectomy. With performance of TAMIS the operation is aimed at performing a primary anastomosis following transanal resection. TAMIS has not been performed for patients with Crohn's disease, however one could imagine possible indications for TAMIS resections for example in case of low rectal stenosis or high supra-anal fistulae. Just recently Tasende *et al*[59] have published their short term outcomes in a prospective case series of patients with ulcerative colitis that underwent proctocolectomy and J-pouch formation in a three step procedure using a combined laparoscopic/natural orifice specimen extraction (NOSE) approach with transanal minimally invasive completion proctectomy. Initial subtotal colectomy with terminal ileostomy was performed laparoscopically in a NOSE approach with the colon being removed transrectally. In the second operation ileostomy removal and pouch formation was performed and followed by transanal proctectomy and performance of anastomosis. Ultimately in the third operation reversal of loop ileostomy was performed. A total number of 16 patients were included with mean operative times of 162.2 min (SD 40.5) for the first step and 170 min (SD 50.1) for the second step. Three months after ileostomy reversal patients had a mean 24 h defecation frequency of 5.5 (SD 1.7), which is comparable to results published in the literature. The majority of patients (75%) could retain stools for more than 30 min indicating sufficient function of the anal sphincter.

Altogether the results open a promising possibility for further development of the technique.

CONCLUSION

Taken together, published data so far has shown feasibility of laparoscopic approaches for primary, recurrent and complicated cases of IBD. Interpretation of the data is still limited by a small number of randomized trials with low numbers of patients being enrolled. Especially for complicated cases of penetrating disease careful selection of patients together with a high level of laparoscopic expertise seems to be the main influencing factor for good short and long term outcomes. Studies investigating the best population that would benefit most by laparoscopic approaches are still missing. However today, in specialized centers primary resections such as ileocecal resection for Crohn's disease or restorative proctocolectomy for ulcerative colitis are almost routinely performed at least with laparoscopic assistance[5].

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