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## Pouch reconstruction in the pelvis

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**Abstract** *Ileal pouch reconstruction:* Proctocolectomy with ileal pouch – anal anastomosis (IPAA) is the procedure of choice in mucosal ulcerative colitis (MUC) and familial adenomatous polyposis (FAP). Because the disease is cured by surgical resection, functional results, pouch survival prognosis, and disease or dysplasia control are the major determinants of success. There is controversy as to whether the IPAA should be handsewn with mucosectomy or stapled, preserving the mucosa of the anal transitional zone. Crohn's disease is a contraindication for IPAA, but long-term outcome after IPAA is similar to that for MUC in patients with indeterminate colitis who do not develop Crohn's disease. As development of dysplasia and cancer in the ileal pouch have been reported, a standardized surveillance program is mandatory in cases of MUC, FAP, and chronic pouchitis. *Colonic pouch reconstruction:* Construction of a colonic pouch is a widely accepted technique to improve functional outcome after low or intersphincteric resection for rectal cancer.

Several randomized studies comparing colo-pouch-anal anastomosis (CPA) with straight coloanal anastomosis (CAA) have found the pouch functionally superior. Most controlled studies cover only 1-year follow-up, but randomized studies with 2-year follow-up show similar functional results of CPA and CAA. Evacuation difficulty as initially observed was related to pouch size, and the results with smaller pouches (5 – 6 cm) are more favorable, showing adequate reservoir function without compromising neorectal evacuation. The transverse coloplasty pouch may offer several advantages to J-pouch reconstruction. Current series question whether the neorectal reservoir is the physiological key of the pouch, but rather the decreased motility. The major advantage reported with colonic pouch reconstruction is the lower incidence of anastomotic complications.

**Keywords** Ileal pouch · Ulcerative colitis · Familial adenomatous polyposis · Colonic pouch · Rectal cancer

Dedicated to Prof. Dr. E. Kern on the occasion of his 80th birthday

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### Introduction

Continence is known to be one of the most important basis of quality of life, and severe psychological implications and social restrictions with impaired continence have been documented. Fecal continence mechanisms involve a coordinated interplay of various factors including stool consistency, transit time, rectal compliance,

rectoanal sensation, neural integrity including extrinsic and intrinsic receptor functions, rectoanal inhibitory reflex, and intact puborectalis and sphincter musculature. These components are affected differently by the variety of sphincter-preserving but rectum-sacrificing surgical procedures that have been introduced for mucosal ulcerative colitis (MUC), familial adenomatous polyposis (FAP), and rectal cancer.

Regarding rectal cancer surgery, a possibly contradictory issue – optimal oncological resection on the one hand, best function on the other – is particularly evident in the curative treatment of midrectal or distal rectal cancer. Improvement in surgical technique with total mesorectal excision (TME) clearly shows that 85% of carcinomas can be resected by sphincter preservation without compromising oncological radicality [1, 2]. Local recurrence rates have decreased and survival prognosis improved [3]. However, increased stool frequency, urgency, and incontinence may be expected after ultralow or intersphincteral resection with straight coloanal anastomosis (CAA) based on the removal of the rectum. To overcome the loss of the adaptive rectal reservoir the colonic J-pouch has emerged as a valuable surgical option to improve functional outcome [4, 5].

Focusing on ileoanal reservoir construction, restorative proctocolectomy with ileal pouch – anal anastomosis (IPAA) has become the surgical therapy of choice for severe MUC and FAP. The procedure combines cure of colonic disease and eliminates the need for a permanent ileostomy. As the pouch is created from ileum, it may retain certain ileal characteristics, but because of its location it may gradually adapt to “neorectal” function. However, previous studies reported that up to 50% of patients with an IPAA may experience functional impairment such as increased stool frequency, urgency, soiling, and disorders of evacuation [6].

To objectively assess current concepts, controversies and challenges of pouch reconstruction in the pelvis, the indications and contraindications, technical details and pitfalls, and surgical and functional results must to be critically reviewed.

### **Ileal pouch reconstruction for MUC and FAP**

The main indications in which the construction of an ileoanal pouch has transformed surgical management over the past two decades are MUC and FAP. Since the first description of ileal pouch – anal reconstruction two decades ago [7, 8] restorative proctocolectomy with IPAA has become the surgical procedure of choice for the definitive treatment in patients with MUC and FAP. The aim of IPAA is to remove the entire potentially diseased colorectal mucosa, which is ideally maintained by this surgical option.

#### **IPAA for mucosal ulcerative colitis**

Prior to the introduction of IPAA proctocolectomy with permanent ileostomy was the gold standard for MUC. Since MUC is confined to the colon and rectum, this type of surgery cures the patients, allows them to discontinue anti-inflammatory medication, and restores them to

health. Regardless to the social impairment of the permanent ileostomy, up to 30% of patients suffered from stoma-related complications including prolapse, stenosis, retraction, parastomal hernia, high ileostomy output with electrolyte imbalance, and dehydration [9]. Despite surgical advances in ileostomy creation and stoma care the psychological adjustment to the presence of a permanent and incontinent stoma in these particularly young patients is considerable, and the introduction of a continent reservoir (Kock pouch) with an intussuscepted small bowel segment as valve mechanism had an unsatisfactorily high incidence of dyssfunction requiring frequent reoperations [10]. Although long-term data on outcome are not yet available, the new T-pouch concept (isolating the terminal segment of the small bowel with its blood supply) described by Kaiser and colleagues [11] may be suitable as continent stool reservoir which promises a significant improvement when compared to the traditional Kock pouch. These type of continent ileostomy seems to be an alternative in a minority of patients who either are not candidates for an IPAA, have failed an IPAA, or who prefer a permanent ileostomy for other reasons.

To avoid imperfect continence after surgery another alternative prior to proctocolectomy with IPAA was total colectomy with ileorectal anastomosis (IRA) [12]. Theoretically, because of the rectum is left in situ, there is no risk of autonomic nerve injury, and physiological defecation is maintained. However, as the rectal mucosa is nearly diseased in all patients with MUC, this type of operation is not curative and includes the potential of persistent and progressive disease in the retained rectal stump. Moreover, MUC entails a risk for the development of colorectal cancer, and the sequence of chronic inflammation with up-regulation of epithelial repair mechanisms, dysplasia, and cancer is commonly accepted as pathomechanism. Therefore IRA is not justified as surgical option in the curative treatment for MUC.

However, despite proctocolectomy with IPAA there is the need for regular follow-up examinations including random biopsies, as aneuploidia and dysplasia have been documented in the mucosa of the ileoanal pouch after years-long inflammation in form of “backwash ileitis” (before surgery) or pouchitis (after IPAA) [13]. Analyzing the incidence of ileal cancer after proctocolectomy with ileostomy, Kock pouch, or IPAA, it is remarkable that there is a latency of up to 38 years after primary operation [13]. Therefore, diagnosis of high-grade dysplasia in an ileal pouch following proctocolectomy for MUC are absolute indications to excise the pouch.

#### **IPAA for familial adenomatous polyposis**

FAP is an inherited, autosomal-dominant syndrome caused by a germline mutation of the APC gene. Clinical diagnosis of FAP is usually based on the presence of

more than 100 colorectal adenomatous polyps, which are thought to progress to colorectal cancer in unidentified or untreated subjects in 100% of cases. The only effective treatment to decrease cancer morbidity and mortality is prophylactic surgery. For many decades proctocolectomy with permanent ileostomy was the only radical surgical option. To preserve anal continence for as long as possible surgical radicality was compromised by introducing total colectomy with IRA, which has been the most commonly performed surgical procedure for many years. Despite regular endoscopic follow-up, however, several registries reported an increased incidence of rectal cancer in patients who had undergone IRA [14, 15]. Following the results of the Swedish Polyposis Registry, the cumulative rectal cancer morbidity and mortality 20 years after colectomy with IRA for FAP was 12.1% and 7%, respectively. Moreover, the cumulative rectal excision rate 35 years after IRA was 65.5% [16]. Additional data from the Swedish Polyposis Registry clearly showed major advantages of IPAA [17]. This study compared surgical, functional, and oncological outcome of IPAA as primary surgery, IPAA as secondary procedure after colectomy with IRA, and IRA alone. Surgical outcome of IPAA did not differ significantly from IRA, and excision rate was low. Despite the superior functional results of IRA (continence, nocturnal stool frequency), no cancer occurred after IPAA, either in the ileal pouch or in retained rectal mucosa, but two of the patients with IRA developed rectal cancer [17]. Therefore the risk of rectal excision and the incidence of rectal cancer after IRA must be considered in selecting patients for primary surgery for FAP. Although randomized studies have not been conducted, the data confirm that patients with FAP, particularly those with dense polyposis, should undergo restorative proctocolectomy with IPAA as primary surgical treatment, while colectomy with IRA is no longer justified. Furthermore, the recommendation that colectomy with IRA is justified in patients with attenuated FAP must be critically reviewed, as the occurrence of rectal cancer despite of chemoprophylactic use has recently been reported [18].

IPAA: stapled or handsewn, with mucosectomy or preservation of the anal transitional zone?

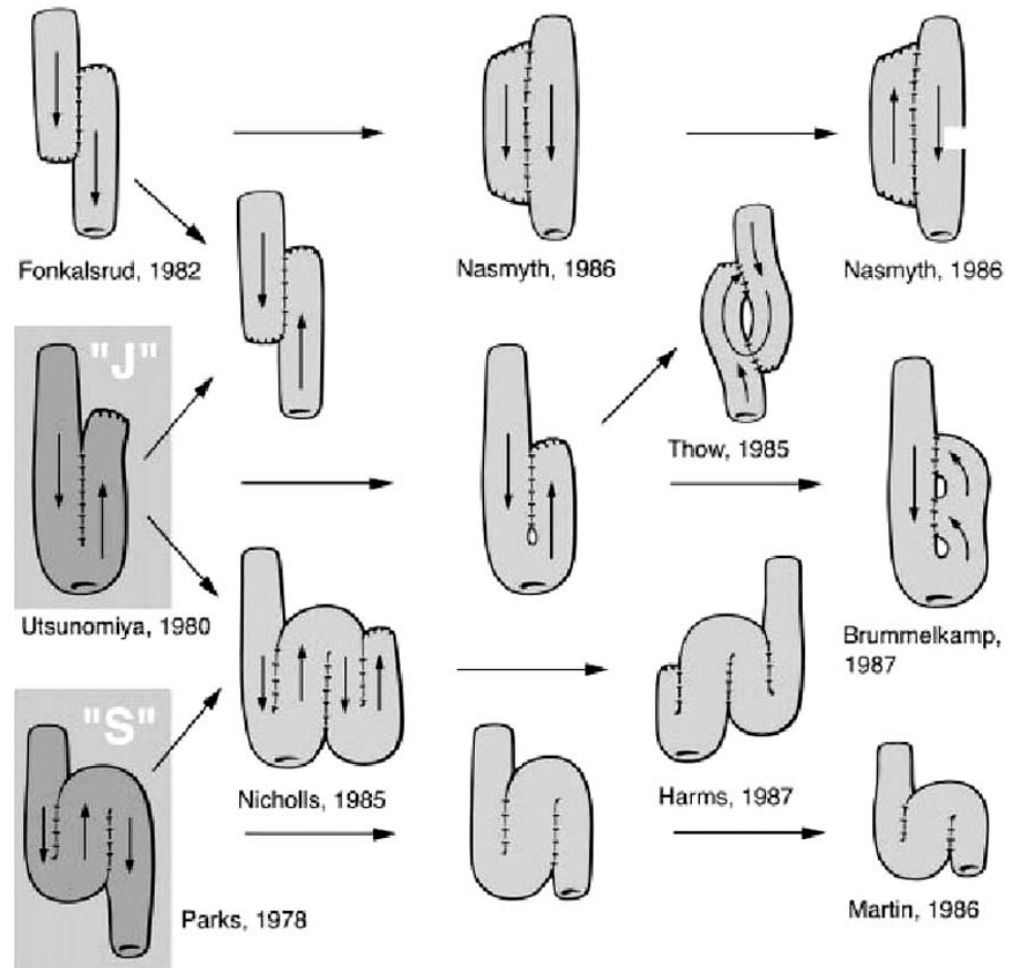
During the past two decades many technical issues of the IPAA have been addressed and resolved toward improving surgical and functional outcome. Following the initial pouch reconstruction types by Parks (S pouch) and Utsunomiya (J pouch), a variety of modifications in pouch design were observed (Fig. 1). However, concerning long-term functional results no significant differences between the pouches were noted [19]. With the introduction of double-stapling technique the stapled J-pouch replaced the S-pouch in most cases, and the length of the rectal cuff has been retained at 2–3 cm.

As the double-stapling technique for IPAA has rapidly gained popularity because of good functional results, there is controversy whether IPAA should be handsewn with mucosectomy or performed by double-stapling technique in which the mucosa of the anal transitional zone (ATZ) is preserved. Advocates of complete mucosectomy with handsewn anastomosis for MUC have argued that there is a higher risk of subsequent dysplasia and malignancy, recurrent mucosal inflammation, and exacerbation of extracolonic manifestations in avoiding a mucosectomy [20]. On the other hand, advocates of stapled IPAA argue that preserving the transitional mucosa of the anal canal improves functional outcome, while the risk of dysplasia and cancer in the ATZ is low and self-limiting. Long-term data from the Cleveland Clinic in Ohio, USA, on the incidence and natural history of dysplasia of the ATZ after stapled IPAA for MUC confirm that ATZ dysplasia is infrequent, is most common in the first 2–3 years postoperatively and may disappear on repeated biopsy [21]. ATZ preservation did not lead to the development of cancer after 5–10 years of follow-up [21]. Recently published results from the same group show that ATZ preservation after stapled IPAA does not lead to the development of cancer with a minimum follow-up of 10 years [22]. These findings have also been confirmed by recent data on regular biopsies of the columnar cuff mucosa following IPAA for MUC with a 12-year follow-up [23]. Therefore long-term surveillance is mandatory, and if repeat biopsy confirms persistent dysplasia, mucosectomy with perineal pouch advancement and neoileal pouch reconstruction is a valuable option.

However, the issue remains controversial, and other authors excise the anal mucosa and perform a handsewn IPAA at the dentate line, without conserving a rectal muscular cuff [24]. To evaluate differences in functional outcome between MUC after restorative proctocolectomy and stapled IPAA relative to the type of tissue in the stapled doughnut, recent data from the Cleveland Clinic in Florida, USA, show that the tissue type in the distal doughnut does not significantly affect functional outcome. The authors conclude that the failure to identify a relationship may attest to the variable height and composition of the ATZ [25].

As long as there are no randomized studies comparing the long-term results related to dysplasia or cancer, no general recommendation is possible as to whether mucosectomy is indicated; however, based on the findings of valid studies from expert centers with long-term follow-up, mucosectomy may be not necessary [22, 23]. To highlight the controversy of stapled IPAA with ATZ preservation vs. handsewn IPAA with mucosectomy from the technical aspect, it is advisable to perform stapled IPAA between the ileal pouch and the proximal end of the anal canal (1–2 cm cephalad the dentate line) only if preoperatively MUC-associated dysplasia is excluded. Concerning surgical technique, a randomized trial to determine the op-

**Fig 1** Differences in pouch design. (Adopted from [19])



timum level of stapled pouch – anal anastomosis showed that stapled pouch – anal anastomosis at the top of anal columns provides better functional results than stapled anastomosis at the dentate line [26]. Long-term surveillance is mandatory in all patients with stapled IPAA to monitor dysplasia. If repeat biopsy confirms persistent dysplasia, excision of the ATZ with construction of neo-IPAA is recommended. In patients with MUC-associated dysplasia or cancer of the rectum within 8 cm of the anal verge, proctectomy with mucosectomy and handsewn anastomosis is recommended as primary operation. Considering the controversy, one must emphasize that there is no evidence for generally recommending mucosectomy as standard in patients with MUC without dysplasia, as “complete” removal of mucosa does not seem to be possible.

In terms of FAP, the tradeoff of superior neoplasia control and better functional outcome is also controversial. Randomized trials comparing the two techniques related to the risk of developing adenomas or malignancy do not exist. Two prospective randomized studies analyzing functional outcome found no significant differences after stapled or handsewn IPAA [27, 28].

If the pouch – anal anastomosis is performed by double-stapling technique, the procedure is technically quicker and less likely to contribute to functional problems. However, technically, to allow transanal insertion of the stapler head, it is usually necessary to leave a 1- to 2-cm strip of rectal or transitional mucosa that is subsequently at risk of developing dysplasia or malignancy. Recent data from the Cleveland Clinic in Ohio comparing outcomes after mucosectomy with handsewn IPAA with those after stapled IPAA show that patients with FAP undergoing stapled IPAA have better functional outcome, and that avoidance of a protective ileostomy is more common. However, there was a 28% incidence of adenomatous polyps in the ATZ after stapled IPAA [29]. Current results from the Dutch Polyposis Registry indicate that the cumulative risk of developing a polyp at the anastomotic site within 3.5 and 7 years after primary surgery for FAP differs significantly between stapled IPAA with preservation of the ATZ (18% vs. 31%, respectively) and handsewn IPAA with mucosectomy (8% vs. 10%, respectively) [30]. Based on these two series, the importance of a regular, life-long surveillance program

of patients with FAP is clear. Following the results of the Dutch registry, it is also clear that patients with FAP who undergo either a stapled or handsewn anastomosis including mucosectomy have a substantial risk of developing adenomatous polyps or malignancy at the anastomotic site independently related to the type of primary type of IPAA [30]. Not surprisingly, case reports of adenocarcinomas after IPAA for FAP or MUC show that cancer development is not restricted to stapled IPAA but also occurs after handsewn IPAA with mucosectomy [13, 31, 32, 33, 34, 35]. Possible explanations for this is that rectal mucosa may be inadvertently retained despite mucosectomy, incomplete surgery, or preoperative backwash ileitis in MUC.

Moreover, a prospective study of 38 patients with MUC and FAP who underwent restorative proctocolectomy with stapled IPAA including either high or low anal transection assessed the distal “doughnut” histologically [36]. The study found that 19 of 20 patients after high anal transection vs. 16 of 18 with low transection had columnar epithelium of the ATZ in the distal “doughnut.” Nine patients (two after high transection, seven after low transection,  $P < 0.05$ ) had striated muscle in the stapled distal “doughnut.” Despite attempts to place a stapled pouch – anal anastomosis below the ATZ it was not possible to remove columnar mucosa completely from the remaining anal canal in the majority of patients (16/18). The authors concluded that high anal transection with stapled IPAA should be the preferred option, as a dentate-line anastomosis may not fully eliminate columnar epithelium and may involve resection of parts of external sphincter [31].

#### Ileal pouch in MUC- or FAP-associated colorectal cancer

A relatively high percentage (up to 8%) of the patients with MUC or FAP already have colorectal cancer at the time of primary surgery. The appropriate treatment policy in these patients remains controversial because an ileoanal pouch may compromise the ability to enroll these patients to adjuvant therapy, and the adjuvant therapy itself may compromise pouch function. Although IPAA can readily be adapted to conform to oncological principles (e.g., lymphadenectomy, TME), the effects of oncological resection on ileal pouch function are not known. The impact of both IPAA on cancer outcome and of cancer treatment on IPAA function was assessed by Radice and colleagues [37]: In their series of 1,616 patients undergoing IPAA for MUC and FAP, 77 had colorectal cancer at time of surgery. There were no differences between cancer and noncancer patients in complication rate, pouchitis, and functional outcome regarding median stool frequency and incontinence. Chemotherapy complications occurred in 15%; one patient developed radiation enteritis. Pouch failure occurred in 16%

of cancer patients, compared with 7% in the overall series. Therefore, although pouch failure is more common, IPAA can be performed in the setting of MUC- or FAP-associated cancer without significant impact on oncological outcome or long-term IPAA function [37]. In general, because of the susceptibility of the small bowel to radiation injury, neoadjuvant therapy for advanced tumor stages may reduce pouch failure rates. Particularly in patients with MUC- or FAP-associated rectal cancer the accuracy of preoperative staging is often difficult, and the presence of unrecognized advanced disease is more common. Therefore the indication to preoperative radiation therapy should be favored in order not to obstruct the possibility of pouch reconstruction. If advanced rectal cancer is diagnosed intraoperatively, one option is to perform oncological resection with creation of an ileostomy, and proceed with mucosectomy and IPAA after completion of radio-chemotherapy in a second-stage operation.

#### Contraindications for ileal pouch construction

The outcome of IPAA performed in patients with Crohn’s disease is distinctly different from that in patients with MUC. Following IPAA for Crohn’s disease there are high rates of pelvic sepsis, anorectal recurrence, fistulas, abscesses, and pouch failure requiring salvage surgery. Therefore Crohn’s disease including perineal and ileal disease remains a contraindication for IPAA [38, 39]. However, in about 10% of patients with inflammatory bowel disease, pathologists are unable to make a definitive diagnosis of Crohn’s disease or MUC even after receiving the proctocolectomy specimen. The histopathological ambiguity in these patients has been defined as “indeterminate colitis” (IC). The majority of IC cases are in patients in whom the diagnosis of MUC was firmly established preoperatively, but in whom the pathologist is unable intra- or postoperatively to confirm the diagnosis of Crohn’s disease or MUC. However, 20–50% of patients with histologically confirmed IC are found to have Crohn’s disease, with potential impact of further surgery [40]. In the past decade several series have focused on the outcome of IPAA for IC but have reached contradictory results. In the Lahey Clinic experience 50% of patients with IC experienced complications, as opposed to 3% of those firmly having MUC; the risk of eventual ileostomy was 0.4% in patients with MUC vs. 28% in patients with IC [41]. Other series indicated that in patients undergoing IPAA for IC, in whom the diagnosis ultimately became Crohn’s disease, the pouch failure rate was remarkably higher, ranging up to 37% and 45%, respectively [39, 42]. Another study found the pouch failure rate in patients with IC to be so extraordinarily high that ileoproctostomy was recommended over IPAA [43]; however, it should be noted that many of

these patients had concurrent or prior perianal disease such as fistulas and abscesses, clinically suspicious for Crohn's disease. Other series show favorable outcomes after IPAA for IC [40, 44, 45]. A Canadian study clearly demonstrated that while prior perianal disease increases the risk of anastomotic leak after IPAA, the overall pouch failure rate did not significantly differ between the groups presenting with prior perianal disease or not [44]. Data from St. Mark's comparing patients with probable Crohn's disease, MUC, and IC showed that patients continuing with the diagnosis of IC are not likely to have Crohn's disease in the long-term and show no difference in functional outcome following IPAA [45].

Regarding the long-term results of IPAA for MUC, IC, and Crohn's disease two recently published series have tremendous impact on surgical guidelines [46, 47]. The Cleveland Clinic experience comparing function, morbidity, and quality of life after IPAA for MUC and IC in a total of 1,911 patients (115 with IC) showed equal results in terms of function, quality of life, and incidence of anastomotic complications and minor pouch fistulas. Although patients undergoing IPAA for IC were more likely to develop minor perineal fistula, pelvic abscess, and Crohn's disease, the rate of pouch failure was 3.4%, identical to that documented for MUC patients [46]. Recent data from the Mayo Clinic determining the long-term outcome of IPAA in patients with IC ( $n=82$ ) compared to a series with MUC ( $n=1,437$ ) demonstrated that 10 years after the operation patients with IC had significantly more episodes of pelvic sepsis (17% for IC vs. 7% for MUC), pouch fistulas (31% for IC vs. 9% for MUC), and pouch failure (27% for IC vs. 11% for MUC). Decisively, during follow-up 15% of patients with IC but only 2% with MUC had their primary diagnosis changed to Crohn's disease. Consequently, when the outcomes of these patients newly diagnosed with Crohn's disease were considered separately, the rates of complications and pouch failures for the remaining patients with IC was identical to that of patients with MUC [47]. Similar functional results and complications following IPAA for MUC have also been reported by two other expert centers [48, 49].

Both studies therefore highlight the impact on IPAA for IC and Crohn's disease. In general, IPAA does not show unfavorable long-term outcome in terms of function, quality of life, pouch-related morbidity, or pouch survival rates in patients with IC who do not develop Crohn's disease. In these patients long-term outcome is nearly identical with that reported for MUC. However, Crohn's disease, whether it develops after surgery for presumed MUC or IC, is associated with poor prognosis including remarkably high rates of pelvic sepsis, pouch failure, and pouch salvage surgery potentially ending in the creation of permanent ileostomy. Therefore histologically confirmed or clinically presumed diagnosis of Crohn's disease is a contraindication for ileoanal pouch reconstruction.

#### Laparoscopic-assisted proctocolectomy with ileal pouch construction

The advantages of laparoscopic surgery include early return of bowel function, reduction in pain, decreased disability, shorter hospitalization, less adhesions, reduced immunosuppression, and better cosmesis. These benefits have been well established for the surgical treatment of benign colorectal diseases [50]. In MUC two surgical options have shown to be laparoscopically assisted feasible and safe: total colectomy with end ileostomy and proctocolectomy with IPAA [51, 52, 53, 54, 55, 56, 57]. In terms of total colectomy with end ileostomy for chronic or acute nonfulminant MUC, several studies have shown that morbidity rates of laparoscopic vs. conventional operation do not significantly differ, whereas advantages of the laparoscopic method were observed in a faster recovery, shorter hospitalization, and decreased blood loss intraoperatively [51, 52]. Concerning standard surgical option for MUC, several series have compared laparoscopic-assisted and conventional proctocolectomy with IPAA [53, 54, 55, 56, 57]. Although the laparoscopic method was shown to be feasible and safe, the well-known benefits of the minimally invasive method were not as clear as those reported for other benign colorectal diseases, and duration of surgery was prolonged [53, 54, 55, 56, 57]. However, since most patients suffering from MUC are young and often present with immune dysfunction, laparoscopic-assisted proctocolectomy with IPAA should therefore be the preferred surgical option in expert centers, providing better cosmesis, and less immunosuppression particularly in this group of patients.

#### Conclusion: determinants of success of ileal pouch construction

Proctocolectomy with IPAA remains the procedure of choice for patients with MUC and FAP. Because of the disease is cured by surgical resection, functional results, pouch survival prognosis, and disease or dysplasia control are the major determinants of operative success. To date, several studies focusing on functional long-term outcome of ileoanal pouch function are available showing that the risk of pouch failure increases with time [58, 59]. In terms of pouch survival prognosis, nearly one-half of the patients with Crohn's disease have been reported to require pouch excision after IPAA [38, 39], and other common causes of pouch failure are obstruction, pelvic sepsis, fistula, stricture, severe pouchitis, and pouch dysfunction [6, 18, 58, 60, 61, 62, 63, 64]. A recently published study indicated that pouch failure is most commonly caused by fistula, and rarely caused by pouchitis [62]. In general, the most common complications after IPAA are small bowel obstruction due to

adhesions [65, 66]. A multivariate data analysis by Heuschen and colleagues [67] found independent risk factors for ileal-pouch-related septic complications to be a systemic prednisolone-equivalent corticoid medication of more than 40 mg/day in patients with MUC, and patients with FAP proved to have a higher risk of pouch-related septic complications if anastomotic tension had occurred. Although the complication rate is known to decrease with increasing experience [6, 18, 58], long-term pouch failure rates are reported between 0.8% and 9% [6, 58, 59]. In terms of pouch failure there are various surgical options for managing these patients, ranging from pouch excision or diversion to reconstructive procedures including perineal ileoanal anastomotic revision, transabdominal ileal pouch revision, and combined perineal and transabdominal revision. Successful pouch salvage rates are reported to range from 50% to 85% [68, 69, 70].

Technical innovations during the past two decades such as the ileal J-pouch configuration and the introduction of stapled IPAA without mucosectomy have decreased short-term morbidity and improved continence. Several series followed up their patients more than 10 years and demonstrated good to excellent daytime and nighttime continence after IPAA [58, 59, 71, 72]. Although age is not independently related to deterioration in ileal pouch function [18, 59, 71], length of follow-up is shown as important predictor of deterioration in pouch function [59, 71]. Both Farouk et al. [71] and Bullard et al. [59] have shown that patients followed up more than 12 years after IPAA are three times more likely to have worsening pouch function than those followed up for less than 12 years. This phenomenon may perhaps be explained by J-pouch configuration (instead of S-pouch) and stapled IPAA, as mucosectomy has been reported to worsen sphincter function and continence [29, 73].

Unfortunately, inflammation and dysplasia may affect ileal pouch, ATZ, and the columnar cuff after IPAA [21, 74, 75]. However, data on cumulative risks do not exist. A prospective study on morphological changes in ileal pouches found no case of mucosal dysplasia in 37 patients followed up for more than 5 years after IPAA for MUC or Crohn's disease [74]. As development of dysplasia, adenomas, and cancer after IPAA has been reported [13, 31, 32, 33, 34], a standardized surveillance program with regular endoscopy (random biopsies) is mandatory, both in those undergoing IPAA for MUC and FAP and in those suffering from chronic pouchitis. Particularly in patients with long-standing pouchitis, a coloniclike pouch mucosa with severe and persistent villous atrophy (type C pattern) may develop in which neoplastic transformation (dysplasia, aneuploidy) can occur [76]. In these patients clinical monitoring with repeat biopsies is necessary, and further studies of histological and molecular events are mandatory.

## **Colon pouch reconstruction after sphincter-preserving surgery for rectal cancer**

During the past two decades important surgical and adjuvant therapy goals have been to improve oncological and functional outcome in patients with midrectal or distal rectal cancer [1, 2, 3, 77, 78, 79, 80]. As surgical techniques have clearly improved, the rate of curative resections and sphincter-saving procedures for rectal cancer have been significantly increased [81]. The technical feasibility of low, ultralow, or intersphincteral resection with CAA has increased with the advent of circular stapling devices and with the knowledge that distal resection margins of 2 cm are oncologically adequate [1, 2, 3, 77, 78, 79, 80]. Moreover, TME with tumor-free lateral resection margins has been recognized as important aspect of oncological radicality [82, 83]. The CPA has proven valuable in improving functional outcome. Finally, adjuvant and neoadjuvant radio-chemotherapy has had a great impact on both local recurrence and survival prognosis [80].

### **Oncological outcome of sphincter-saving resections**

With the introduction of TME, local recurrence rates have been reliably decreased below 10% after curative resection. Surgical dissection along the connective tissue space between rectal and parietal pelvic fascia with complete mesorectal excision results in reliable excision of all relevant lymphatic pathways with preservation of continence and sexual function. Both removal of complete TME specimen and careful pathological examination of the circumferential resection margin have decisive significance [82, 83]. As a spread of tumor distally along the bowel wall rarely exceeds a few centimeters, a distal resection margin of 2 cm is oncologically sufficient in sphincter-saving procedures without compromising prognosis. Hida and colleagues [84] recently examined the distal spread of rectal cancer within the mesorectum and detected lymph node metastases up to 4 cm distal to the tumor in 20% of patients with pT3 carcinoma. Providing TME, all these positive nodes can be resected, and sphincter preservation can be achieved in the majority of patients suffering from cancer of the middle rectum. In terms of prognosis, sphincter-saving resections can be performed for midrectal or low rectal cancer without an increased risk of local recurrence, and CAA has not compromised oncological results [77, 85, 86].

### **Functional outcome: from straight CAA to CPA**

Despite sphincter-preserving surgery some authors were discouraged by functional results following straight CAA. Poor function is seen not only in increased stool frequency,

soiling, and urgency but in evacuation disorders. Soiling may be attributable to decreased anorectal sphincter resting pressures, while frequency and urgency are believed to be due to diminished reservoir capacity, which is directly proportional to the amount of rectum removed and the level of anastomosis [87, 88, 89]. As these poor functional results of straight CAA are associated with the loss of the rectal reservoir, Lazorthes et al. [4] and Parc et al. [5] independently presented the concept of colonic J-pouch. To increase reservoir capacity, Lazorthes and colleagues [4] created a colonic J-pouch in conjunction with CAA through a posterior transphincteric approach. At 1-year follow-up 86% of patients with CPA with a colonic reservoir (6- and 12-cm stapled J pouches) had fewer than three stools per day, compared to 33% of patients with straight CAA. They observed an inverse association between defecation frequency and the maximum tolerated volume of the neorectum, supporting the hypothesis that improved pouch function is at least partly related to increased maximum tolerated volume [4]. Parc and colleagues created an 8-cm pouch constructed from middle to upper sigmoid colon. Following mucosectomy from 5 mm cephalad to the dentate line to the level of the levator-anorectal junction, the pouch was delivered into the muscular sleeve, and the CPA was hand-sewn to the dentate line. Three months after take-down of diverting transverse colostomy the mean number of bowel movements was 1.1 per day. However, 25% of patients showed impaired evacuation [5].

### Colonic pouch procedures

Pouch procedures require several technical considerations which have been standardized in oncological resection for rectal cancer including complete mobilization of the splenic flexure, high ligation of the inferior mesenteric artery and vein, no-touch technique, and pouch construction from a well-vascularized distal colon segment. Both the sigmoid colon and descending colon have been used for pouch reconstruction. As the sigmoid colon often shows diverticular disease, it may not be suitable for pouch reconstruction. Furthermore, as the sigmoid tends to be more muscular than the descending colon ("high-pressure zone") and the vascular supply is often compromised when compared to descending colon, the sigmoid colon has been implicated as a cause of defecatory difficulty, and pouch reconstruction using descending colon has been advocated instead [90]. However, a prospective randomized study comparing the use of sigmoid vs. descending colon for CPA after ultralow anterior resection showed similar bowel function in the two groups in terms of stool frequency, continence, urgency, use of pads and antidiarrheals, sensation of incomplete evacuation, and anorectal physiology results after 1-year follow-up [91]. Nevertheless, as sigmoid colon is usually removed in standard anterior resection due to technical

principles, valid long-term data of sigmoid pouch are not available, and particularly the long-term course of the sigmoid colon related to diverticular disease or intestinal innervation disorders is not definitely known, pouch reconstruction from a well-vascularized descending colon segment may be the favorable option. With mobilization of the splenic flexure and high-tie ligation of the inferior mesenteric artery the length of colon is generally sufficient for a tension-free anastomosis to the low rectum, or the dentate line in terms of intersphincteric resection, and to create a pouch of descending colon.

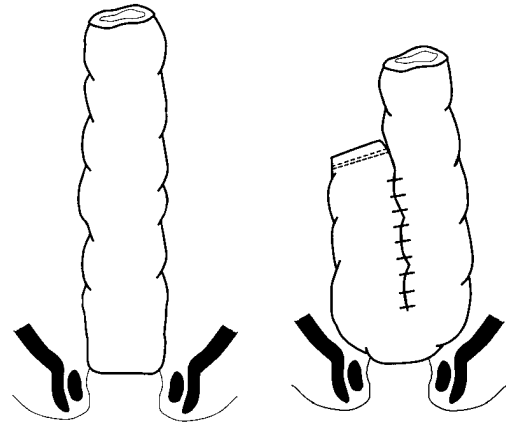
Furthermore, functional results are importantly related to the height of anastomosis, and investigatory results including anorectal physiology testing (e.g., manometry (neo)rectal inhibitory reflex) [92]. Differences between CPA and CAA after ultralow anterior resection tend to disappear with preservation of rectal length. Therefore Hida and colleagues [93] determined the level at which J-pouch construction provides an advantage over CAA. They compared outcomes in 48 patients who underwent 5-cm colonic J-pouch reconstruction and 80 patients who underwent CAA 1 year postoperatively. They found the functional outcome in the J-pouch group to be significantly better than that in the CAA group when the distance of the anastomosis from the anal verge was less than 8 cm. Moreover, they noted that the benefits of the J-pouch reconstruction were clear superior if the anastomosis was below 4 cm from the anal verge. However, if the anastomosis was located 9–12 cm from the anal verge, the functional outcome of CAA was equivalent to that of J-pouch reconstruction when the anastomosis was 5–8 cm from the anal verge [93]. Similarly, Ramirez and colleagues [94] compared functional outcome of CPA with that in ten matched patients who underwent high anterior resection. They showed that the addition of a colonic J-pouch neorectum led to functional results comparable to those seen in patients with a high anastomosis and nearly preserved rectum. Based on these results and other experiences of pouch surgery, colonic J-pouch reconstruction after low anterior resection with ultralow or CAA is indicated when the distance of anastomosis from the anal verge is within 6 cm (low rectal), or superiorly when the distance is less than 4 cm from the anal verge (coloanal). Otherwise, colonic pouch reconstruction has no functional benefit but leads to "iatrogenic" outlet obstruction with severely impaired evacuation.

In addition to the functional success provided that pouch reconstruction following low anterior resection is related to anastomotic height, the data of Hida and colleagues [93] further indicated that the anastomotic leak rate of patients with colonic J-pouch reconstruction and anastomoses 1–4 cm from the anal verge was lower (7.4%) than that observed in patients with straight CAA 1–4 cm from the anal verge (12.5%). Hallböök and colleagues [95] reported similar results comparing CPA (J-pouch) with CAA in a randomized study; the incidence of anastomotic leakage was significantly lower in the

J-pouch group (2%) than in the CAA group (15%). Theoretically the risk of anastomotic leakage from a multistaple line pouch anastomosis would be expected to be higher than that with a single-line straight anastomosis. However, laser Doppler blood flow measurement reported by Hallböök and colleagues [96] shows that the microcirculation at the pouch apex is better preserved than at the bowel end used for straight reconstruction.

Although the short-term functional results of colonic J-pouch were more favorable than those of CAA, incomplete evacuation disorders are initially noted in 10–30% of the patients with colonic J-pouch (8–10 cm). Therefore surgeons tend to construct smaller pouches with a limb length of 5–6 cm. Recently published data of randomized studies comparing small (5–7 cm) and large (8–10 cm) show similar functional results concerning stool frequency, soiling, and urgency but significant reduction in evacuation difficulty with a small pouch size [97, 98]. As improved functional outcome achieved by small-volume pouches (5–6 cm) have been confirmed by randomized studies, various replacement options of rectal reservoir and pouch designs have been clinically evaluated including “ileocecal reservoir” and side-to-end anastomosis [99, 100, 101]. In 1996 von Flüe and colleagues [99] described their method of “ileocecal reservoir” using the ileocecal segment to replace rectum between descending colon and dentate line following low anterior resection. Three months after rectal replacement 87% of the patients were continent with further improvement over 2 years. Nocturnal soiling remained in 44% over 2 years [100]. Huber and colleagues [101] reported their results of stapled side-to-end anastomosis after low anterior resection in a randomized study comparing colonic J-pouch reconstruction (6 cm) with stapled side-to-end anastomosis; they found similar satisfactory long-term functional results in the two types of reconstruction. The major advantage of the colonic pouch was observed in the immediate postoperative phase; however, constipation was documented in 7% of the pouch group vs. none after side-to-end anastomosis [101]. Initially motivated by technical aspects that pouch reconstruction may be more time-consuming than straight anastomosis and technically more demanding in cases with inadequate bowel length, the authors expected the blind end of the bowel to act as “mini-reservoir” and concluded that with a blind end of 4 cm side-to-end reconstruction may be a viable option to the colonic J-pouch, providing comparable results related to capacity and reservoir function [101].

In 1999 Z'graggen et al. [102] introduced the transverse coloplasty pouch (TCP, “Bern-Pouch”). Using the TCP they examined whether a very small colon pouch would decrease the early dysfunctions frequently observed after CAA and the late evacuation difficulty associated with large colonic J-pouches. The TCP augmented the neorectal volume by 40% over the CAA and had a significantly smaller capacity than a colon J-pouch.



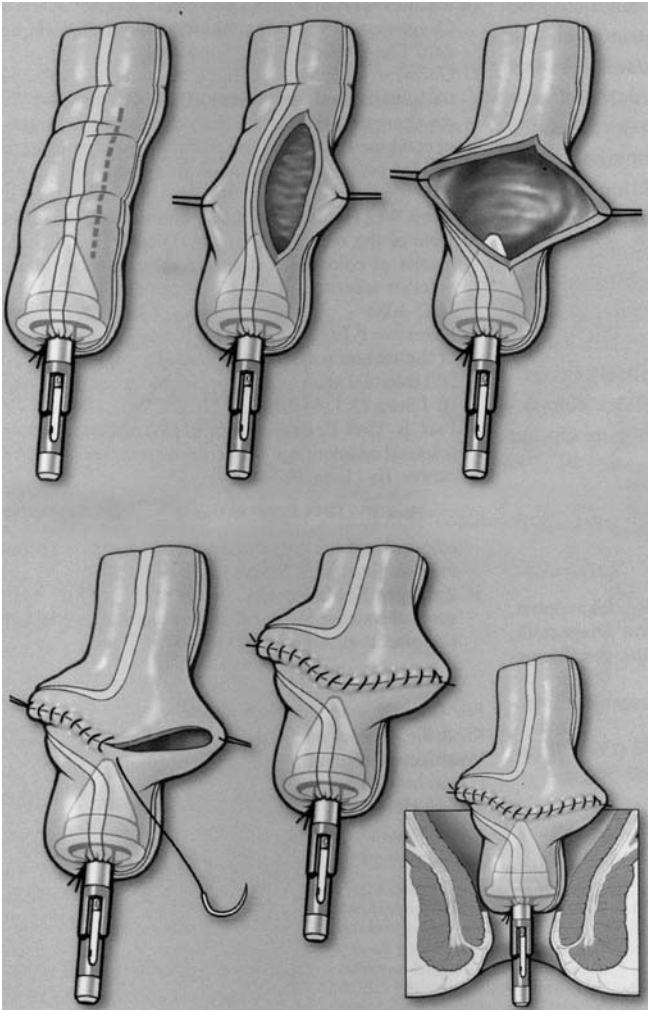
**Fig 2** Straight coloanal anastomosis and colonic J-pouch–anal anastomosis

Technical feasibility was initially tested and compared to CAA and J-pouch in an animal model [102]. From the technical aspect, a segment of descending colon is used to construct the pouch.

Briefly, a purse-string is fitted to the cut end of the colon, the stapler anvil inserted, and the purse-string tied. An 8-cm longitudinal colotomy is performed 2 cm proximal to the rim of the anvil, placed between the two taenia. Lateral traction by stay sutures forms the reservoir and the colotomy is closed by transverse running sutures. Finally, end-to-end stapled anastomosis is performed (usually 33-mm circular stapler), and the anastomosis is defunctionalized for 3 months (Figs. 2, 3) [102, 103, 104]. Regarding surgical results, anastomotic leakage occurred in 7% (3/41). However, the length of colon after pouch reconstruction was sufficient to reach the pelvic floor for a tension-free anastomosis in all procedures, and experimental laser Doppler flow measurements showed that the antimesocolic transverse coloplasty did not negatively affect perfusion proximal and distal to the suture line [102, 103, 104]. Short-term functional outcome of 41 patients was favorable (stool frequency decreased from 3.4 per 24 h at 2 months to 2.1 per 24 h at 8 months of follow-up; stool dysfunction such as urgency and fragmentation decreased after 6 months), and no evacuation problems were observed [103]. Based on these encouraging results, reducing early dysfunction after CAA and avoiding long-term evacuation difficulty after conventional CPA, the TCP was introduced in many centers.

#### Surgical and functional outcome of CAA, CPA, and TCP

The concept of pouch reconstruction after sphincter-preserving surgery for rectal cancer has been evaluated in several studies: In comparison to low colorectal or CAA, functional short-term results of CPA ranging from



**Fig. 3** Surgical technique of the transverse coloplasty pouch. (Adopted from [104])

3 months to 1 year show significantly superior results: decreased stool frequency, greater capacity before feeling the urge of defecation, reduction in soiling, and improved continence scores [105, 106, 107, 108, 109, 110, 111, 112]. The significant benefits of the colonic J-pouch have also been confirmed by randomized studies [87, 95, 98, 113, 114, 115, 116, 117, 118, 119, 120, 121]. However, in contrast to CAA, up to 25–30% of patients with a pouch experience some degree of incomplete evacuation. This phenomenon has been shown to be more problematic in patients with a large colonic J-pouch (8–10 cm) [97, 98].

Since its clinical introduction the TCP with low colorectal or CAA has helped to reduce evacuation difficulty, and preliminary results show favorable functional outcome [102, 103, 104]. The nonrandomized, short-term study by Manyth and colleagues [112] found that patients with a coloplasty pouch achieved the same func-

tional and manometric results as those with a stapled colonic J-pouch rectal anastomosis. Both coloplasty and colonic J-pouch reconstruction had a significantly improved functional outcome related to CAA in terms of decreased stool frequency, pouch compliance, and increased maximum tolerated volume. Therefore neorectal reservoir reconstruction with the TCP is the preferred surgical option particularly in these patients, when additional length for construction of a colonic J-pouch is difficult to reach or is difficult to construct in a narrow male pelvis. Ho and colleagues [119] were the first to compare efficacy between the coloplasty pouch and conventional colonic J-pouch anal anastomosis in a randomized study. The duration of surgery was similar; however, coloplasty pouches resulted in a higher anastomotic leak rate. Short-term functional outcome did not differ between coloplasty and colonic J-pouch.

Randomized controlled trials to date have confirmed the functional superiority of the colonic J-pouch over straight CAA [87, 95, 98, 113, 114, 115, 116, 117, 118, 119, 120, 121]. However, the significant functional improvements have been documented to be beneficial for the early postoperative period (1-year follow-up), and the results from series available with at least 2-year follow-up have not been in complete agreement [98, 109, 110, 118]. Randomized long-term data to date are restricted to two studies [98, 118]. Due to the lack of controlled studies with long-term follow-up, Ho and colleagues [118] conducted a randomized trial to compare clinical outcome, functional results, anal manometry, and rectal barostat findings in patients after ultralow anterior resection reconstructed with either CAA or CPA followed for 2 years. As stool frequency and incontinence were less frequent for the pouch group 6 months postoperatively, the functional results were comparable for CAA and CPA after 2 years [118]. Rectal sensory testing by barostat showed an impairment of sensation, maximum tolerable volume, and compliance 6 months after surgery but recovery or improvement in *both* groups at 2 years, suggesting that recovery of residual afferent sympathetic nerves play a role in regaining function [118].

Despite the time dependency in functional outcome following adaptation of CAA after 2 years, there is another potential advantage of pouch reconstruction. Almost all studies show, in addition to the minimally added technical effort of pouch reconstruction, that morbidity, particularly anastomotic leak, and mortality rates of CPA do not differ or even compare favorably in relation to CAA [87, 95, 98, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121]. Joo and colleagues [109] reported a fourfold reduction in complications (anastomotic leakage, stricture, fistula, bleeding) following CPA vs. CAA. Although a minority of studies have directly compared anastomotic complication rates in relation to anastomotic height, the reported anasto-

motric complication rates reach up to 25% after CAA in the comparative studies, whereas the rates of anastomotic complications following CPA are significantly lower (2–8.7%). Therefore despite the adaptation of CAA observed 2 years after low anterior resection yielded comparable functional results as the pouch the significant reduction in anastomotic complications revealed a major advantage for pouch reconstruction.

#### Is fecal diversion to protect CPA necessary?

The issue of whether a temporary fecal diversion to protect CAA or CPA is not one related specifically the pouch. Previous studies have shown that the lower the level of the anastomosis from the dentate line, the higher the rate of anastomotic complications is following straight CAA, and for this reason most surgeons perform temporary fecal diversion. However, the particular benefit of defunctionalization is neither to protect against anastomotic leakage nor to reduce anastomotic complications. The major advantage of temporary diversion is the reduction in anastomotic leaks *requiring surgery*. This has also been reported by a German multicenter study on the value of a protective stoma in low anterior resections for rectal cancer [122]. Dehni and colleagues [123] reported that patients without a defunctioning stoma in low rectal anastomosis are significantly more likely to suffer a clinical anastomotic leak with peritonitis that requires reoperation. Reflecting on the potential consequences of anastomotic leak to prognosis after curative resection [124], the routine use of a protective stoma (preferentially loop ileostomy) with closure after 3 months is recommended in CAA or CPA [125].

#### Impact of adjuvant radio-chemotherapy on colonic J-pouch function

Randomized studies have reported both improved local recurrence rates and survival prognosis after preoperative radiotherapy followed by curative surgery for rectal cancer [77, 78, 79, 80]. As the addition of chemotherapy may supplement preoperative radiotherapy in eradicating local disease, preoperative radio-chemotherapy enhances the likelihood of being able to perform a sphincter-preserving resection (ultralow or intersphincteral resection) in patients who would otherwise have undergone abdominoperineal excision with permanent stoma [77, 78, 79, 80, 126]. Ongoing controlled trials are currently comparing the role of preoperative short-course radiotherapy with TME as an integral part of surgery and combined preoperative radio-chemotherapy to postoperative adjuvant radio-chemotherapy for resectable UICC stage II and III rectal cancer [78, 80]. However, as regards the impact of adjuvant therapy on anorectal and pouch function, both sphincter and bowel

function may be adversely affected by radiotherapy, and it has been speculated that irradiation of the sphincters leads to fibrosis and bad functional outcome [127, 128]. In terms of functional outcome after preoperative radiotherapy, the results of Rouanet and colleagues [129] are encouraging, enabling sphincter-preserving low ultralow resection with either CAA or CPA in 70% of patients. Morbidity and mortality were not increased with high-dose preoperative radiotherapy [129]. These data have also been confirmed by other studies on the feasibility, morbidity, mortality, and functional outcome after preoperative radiotherapy followed by curative sphincter-preserving surgery with CPA [130, 131].

However, two nonrandomized studies assessing the impact of pre- and postoperative radiotherapy with or without chemotherapy on pouch function found potential adverse effects of pre- and postoperative irradiation on continence and evacuation in patients with colonic J-pouch [132, 133]. Dehni and colleagues [132] compared long-term bowel habits in patients receiving preoperative radiotherapy for distal rectal cancer followed by colonic J-pouch–anal anastomosis with those undergoing similar oncological resection without radiation. All patients in their series had colonic J-pouch reconstruction with manual anastomosis at or directly above the dentate line; radiation was administered either as short- or long-term course. Neither group showed a significant difference in stool frequency, clustering, use of pads, ability to defer evacuation more than 15 min, ability to evacuate the bowel within 30 min, incontinence, or dietary restrictions. However, diarrhea (39% vs. 13%) and nocturnal defecation (36% vs. 15%) were significantly more frequent in the irradiated than in the nonirradiated group [132]. The series of Gervaz and colleagues [133] investigated the impact of adjuvant radio-chemotherapy in patients with stage II and III midrectal or low rectal cancer undergoing low resection with colonic J-pouch reconstruction and CPA. They compared functional outcomes of three different groups, including the surgery alone group, and those patients receiving pre- or postoperative radio-chemotherapy. Patients in the surgery alone group were found to have significantly better continence and less evacuation difficulty. The incidence of functional disorders was significantly higher in the irradiated groups than in the surgery alone group: incontinence to gas (76% vs. 43%), to liquid stool (64% vs. 25%), and to solid stool (47% vs. 11%). Specifically focusing on pouch function, irradiated patients had a significant increase in pouch-related specific disorders, such as clustering (82% vs. 32%) and sensation of incomplete evacuation (82% vs. 32%). Regression analysis demonstrated that radiation-induced sphincter dysfunction was progressive over time [133].

Although radiotherapy may adversely affect continence and evacuation in patients with colonic J-pouch reconstruction, a CPA should not be abandoned simply because of the necessity for radio-chemotherapy due to advanced tumor stage (UICC stages II and III). The con-

sequence of the reported data, however, should be to recommend radio-chemotherapy *preoperatively* in patients with locally advanced disease. Despite the potential advantages of preoperative radio-chemotherapy, which is currently being assessed by controlled studies in relation to prognosis, there is the clear benefit of preoperative radiotherapy that most of the colon used to construct the neorectum is usually not irradiated, and therefore function is less likely to be affected [126].

#### Conclusion: determinants of success of colonic pouch construction

Randomized controlled studies confirm the functional advantages of CPA over straight CAA during the first postoperative year. Moreover, patients undergoing low anterior resection may expect not only better functional results but also improved quality of life in the early postoperative period [117]. Nonetheless, the physiological concept of pouch reconstruction has not been completely elucidated, and available long-term data with at least 2-year follow-up do not indicate unequivocal functional superiority of the pouch. The evacuation difficulty that was initially observed was related to pouch size, and the results of smaller pouches (5–6 cm) are more favorable in conferring an adequate reservoir function without compromising neorectal evacuation. In terms of functional assessment, with proctectomy the natural reservoir is removed and replaced by less distensible colon, and measurable physiological changes that could help to explain functional problems would therefore be expected [128, 134]. However, a randomized study observed no significant differences between CPA and CAA at 2 years in terms of rectal sensation, compliance, or maximum tolerable volume [118]. This is consistent with the improved stool frequency and continence particularly recovered in the long-term course of straight CAA. Furthermore, from anal manometry, early J-pouch

studies indicate significant differences neither between pre- and postoperative resting and squeeze pressures nor between CPA and CAA. Controlled studies report the recto-anal inhibitory reflex in 30/100% of J-pouch patients, as indicator of neurological consolidation of the anastomosis. Interestingly, randomized data have found no significant differences in the maximum tolerable volume or neorectal capacity between a small pouch (5 or 6 cm) and straight CAA either at 6 months [114] or at 2 years [118]. These findings demonstrate that increased neorectal capacity cannot necessarily be taken as a the fundamental indicator of reservoir function. Current randomized data support the hypothesis, rather, that the key to colonic pouch function is delayed propulsive motility [114, 118].

In addition to the improved functional outcome of CPA, a major advantage reported with colonic pouch reconstruction is the lower incidence of anastomotic complications, including leakage, bleeding, and fistula. Therefore, although functional advantages of CPA seem to be significant only during the immediately postoperative period, pouch reconstruction is both beneficial and safe in the strategy of low or intersphincter resection, providing reduced morbidity and mortality rates.

Furthermore, Harris and colleagues [135] have recently analyzed the reasons for failure to construct a colonic pouch in the pelvis, both technical (narrow pelvis, bulky anal sphincters or need for mucosectomy, diverticulosis, insufficient colon length or pregnancy) and nontechnical (complex surgery or distant metastases) [135]. Interestingly, they found significantly lower failure rates with the TCP [135]. The TCP thus offers a safe and beneficial alternative to colonic J-pouch – anal anastomosis, and therefore also ameliorate some of the disappointing results achieved with straight CAA. However, long-term surgical and functional results of the TCP must be evaluated in controlled studies. Perhaps these studies can also confirm the principle of decreased motility as causative factor for pouch reconstruction.

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