Selection of treatment modalities should always be aimed at providing the patient with the best possible quality of life. For patients awaiting rectal resection, it is important to preserve the capacity for bowel and intestinal gas evacuation via a natural pathway. This is true for both patients with rectal malignancies as well as those with familial adenomatous polyposis and inflammatory diseases of the colon. Currently, at least 1/5 of all rectal cancer patients treated with rectal resection still suffer from permanent injury in the form of abdominal fecal fistula (1) Studies of patients who have received low anterior resection and abdomino-perineal resection do not generally indicate a decline in life quality as a result of establishing such a permanent fecal fistula (2, 3). Sphincter-sparing surgery is thought to be the treatment approach of choice in patients with effective sphincter apparatus, as long as infiltration of the sphincter muscles or structures of the bottom of the pelvis is not detected and R0 surgery can be performed safely (4).

After less than two decades of exploration, guidelines were formulated that allow for the choice of optimum treatment modalities in patients with rectal cancer, including the chances to preserve the continuity of the digestive tract. In most patients, it is sufficient to preserve a 2 cm peripheral margin of intact rectal wall, and – if total resection of the mesorectum is not performed – to resect the 4-5 cm distal margin of the mesorectum within the visceral lamina of the rectum. In patients with tumour regression following preoperative radio- or radio-chemotherapy, we maintain the specimen resection line at the level pre-planned before irradiation. The distal 2 cm margin of the intestinal wall may be smaller if intraoperative microscopic examination rules out malignant infiltration within the resection line (5-9). In cases of cancer at low location, it is only allowable to resect the rectum along with part of the anus (particularly including the internal anal sphincter, but also with inclusion of the entire internal and part of the external anal sphincter), if this guarantees appropriate quality of the resection margin and preserves the efficiency of the sphincter apparatus to control defecation (10, 11, 12). Preservation of a rectal stump favours better bowel and gas continence (13).

Rectal resection with excision of the entire or most of the mesorectum changes the anatomical conditions within the pelvis minor and permanently impairs physiological mechanisms controlling bowel and gas movements. The process of bowel and gas continence is controlled by a complex of muscles of the rectum, anus and at bottom of the pelvis; together, they efficiently close and open the anus in response to sensory anorectal reflexes (14, 15). The entire process is inherently linked with compliance of the rectal walls up to a certain degree of distension to preserve an appropriate pressure gradient between two locations: the rectal lumen and the anus itself, both prior to and during the act of defecation (15, 16). Another fac-
Colonic reservoirs in patients after rectal resection

The return of reflexes controlling continence and evacuation of bowel and gases by means of numerous receptors (which are present also within the structures of the bottom of the pelvis) is the presence of tissues filling the space left by rectal-mesorectal resection. This is the objective of creating a volume-equivalent substitute for the removed tissues (17). Moreover, zero dead space within the true pelvis prevents accumulation of potential fluids that favour development of inflammation, purulent process, leakages and other complications; zero dead space also prevents descent of the small intestine into the pelvis minor. Therefore, in each case of rectal resection, production of a volume-equivalent fecal reservoir in the post-resection space, with connection made to the anus or anal stump, instead of a simple end-to-end anastomosis with the colon, should be considered. Leaving up to 7-8 cm of anorectal stump was found to allow restoration of the continuity of the large intestine without a need to produce a fecal reservoir (18).

Following resections within the distal part of the large intestine, we use the colon to restore continuity of intestinal passage. The use of the descending colon instead of the sigmoid, both for production of an intestinal reservoir and for a simple anastomosis, is commonly recommended (18). The sigmoid has a smaller lumen diameter, its wall is less compliant and it is a more common site for diverticuli, which contribute to complications (17). However, results of a randomized trial did not confirm the superiority of the descending colon over the sigmoid (14). We emphasize the fact that utilization of the sigmoid frequently permits physicians to avoid mobilization of the splenic flexure of the colon. Since the rectal regional lymph nodes extend into only as little as 1% of the mesosigmoid, there are no oncological indications for its resection along with the rectum (19). However, it is important to monitor blood supply to the distal end of the sigmoid and to shorten it before the anastomosis, if needed (14). Patient age above 75 years should not be considered to be a contraindication for production of an intestinal fecal reservoir and anal anastomosis (17, 20).

Regardless of the type of reconstruction, it is almost always the case that less or more pronounced symptoms of low anterior resection syndrome develop, lasting up to 1 year or even longer (15,18). Patients complain of frequent bowel movements (also during the night), bowel and gas incontinence, difficulty differentiating between loose stool and gases, a sudden need to defecate, and an incapacity to get rid of the stool within a single defecation act. Therefore, sparing of the anal sphincters depends on the preservation of an efficient sphincter apparatus, which helps limit the symptoms of the syndrome. Radiotherapy as an element of combined treatment of rectal cancer also contributes to impairing the efficiency of the sphincter apparatus (21, 22), particularly to the internal sphincter (23, 24). In cases of rectal cancer, the degree of sphincter impairment due to radiotherapy is similar to that of both pre-operative and post-operative irradiation (4).

On the basis of evaluation of multi-year experience concerning intestinal reservoirs, the J-pouch (JP) technique gained much recognition and appreciation for the treatment of rectal cancer of low location (fig. 1a). A JP reservoir allows achievement of an optimum treatment outcome and improves the patient’s quality of life, particularly within one to two years following the surgery, as compared with patients without reservoirs (10, 25-30). The technique used to produce a JP reservoir is in fact copied from the technique used to construct small-intestine reservoirs that was applied by Utsonomija et al. in the 1970s (31). The common availability and utilization of staplers in surgery contributed to dissemination of that method in the mid-1980s, with substantial addition contribution from the works of Lazorthes and Parc (32, 33). These and other authors’ long-term experiences provided the basis for determining the optimal JP length to be 5-6 cm (17, 25, 34, 35). This reservoir dimension decreases the risk of constipation 1-2 years after the surgery. It was unanimously agreed that the JP technique favours delay of motor activity within the region proximal to the anastomosis with the anus, and that this is the source of benefits with JP compared to so-called “simple anastomosis” without a reservoir, with the creation of a fecal reservoir of a particular volume itself seeming to play a minor role (25, 36). The capacities of a JP pouch and of a loop after a simple anastomosis were demonstrated to be similar after 1 year, even though they were initially different (25). We should remember that the tip of a curved intestinal loop forming an
anastomosis with the distal part of the large intestine in the JP pouch demonstrates better vascularization than does the margin of the resected intestine within the simple anastomosis, which contributes to a decreased risk of leakage within the anastomosis (37). The doubled mesentery of the intestine that is used to form the pouch sufficiently fills in the space emerging after excision of the mesorectum (17).

Difficult anatomical conditions within the pelvis not only hinder resection of the rectum, but also make it difficult to restore continuity of the intestine through the formation of a fecal reservoir. According to many authors, in obese patients with a long and narrow pelvis and a relatively thickened sphincter apparatus, manoeuvres with the JP with abundant mass of the mesentery may increase the risk of complications, and, in 25% of the patients, conditions make JP formation impossible. Safe anastomosis without tension in the suture line is sometimes impossible to achieve due to insufficient length of the intestinal loop (38, 39, 40). For this reason, Fazio et al. suggested the use of coloplasty (CP) as a method to create a fecal reservoir (fig. 1b), a method previously described by Swiss authors (40-43). The authors of that report, Z'graggen et al. (42), tested this model of a fecal reservoir on animals. The technical details of CP allow avoiding a number of difficulties encountered in some patients who underwent the formation of JP (43, 44, 45). One facilitating factor is the lower total volume of fecal reservoir formed with CP.

According to Fazio et al. (41), the colon should be incised longitudinally between the teniae with a length of 8-10 cm and at a distance of 4 cm from the planned line of anastomosis, with the opening sutured in a transverse fashion. Other authors recommend decreasing the distance from the line of anastomosis from 4 to 3 or even 2 cm and making the incision of the intestine with a length of about 5 cm (38, 45, 46). The opening may allow for introduction of the stapler to the region of anastomosis, as is the case with the opening of the flexed JP loop or the distal opening of the colon brought down to the pelvis during the procedure of its side-to-end colo-anal anastomosis (47). Such use of a circular stapler for anastomosis decreases the risk of damage to the sphincter apparatus by eliminating the need for trans-anal manoeuvres with the stapler (47,48). Over the years,

Fig. 1. Types of colonic fecal reservoirs: a – J-pouch, b – coloplasty, c – side-to-end anastomosis, d – ileo-cecal reservoir
Colonic reservoirs in patients after rectal resection has become the frequently used method of choice for forming a fecal reservoir. There are no major differences found with respect to evaluation of the functional outcomes following JP or CP, but the coloplasty technique appears to be simpler and is associated with a lower risk of postoperative complications (38, 39, 40, 44, 49).

A pelvic fecal reservoir can also be formed using a 4-5 cm blind arm of a colonic loop descended to the pelvis and anastomosed side-to-end with the anus (fig. 1c) (47, 50-53). Such an anastomosis was long ago proposed as an alternative to simple anastomoses, pointing to the merits of this method. Authors emphasized the simplicity of the technique performed on the abdominal side, as well as in patients with narrow pelvis, in addition to the lower risk of in-anastomosis stricture (47, 52, 53). Functional studies demonstrated that it was not so much the total volume of the reservoir, but rather the delay caused by the reservoir in motor activity that plays a beneficial role in controlling the symptoms of low anterior resection syndrome. This also favours the SE technique (25, 36, 47, 53). Authors point to more serious technical challenges involved in the forming of JP as compared to SE. The functional outcomes up to 2 years following surgery are similar (47, 53). Although patients with JP achieved better tolerance of particular smaller stool volumes as the cause of sudden defecation, patients with SE anastomosis demonstrated a quicker decrease in the number of bowel movements per day.

For the production of an intestinal reservoir, a segment of the ileum with inverted cecum (ileo-cecal pouch) can also be used (fig. 1d). Such a reservoir is suitable in cases of resectional relapses within the colon and also when a previously formed reservoir is removed together with the recurrence lesion. Ileo-cecal reservoirs should be considered in patients with diverticulosis of the descending colon and sigmoid and whenever hypertrophic, lipomatous mesocolon and narrow pelvis are encountered. The merit of this method is said to be preservation of afferent and efferent innervation (54, 55). For this method, functional outcomes after 3 and 5 years of observation are not significantly different from those obtained in patients with the JP pouch (54).

A fecal reservoir can also be formed by excision from the distal segment of the colon of a part of the counter-mesenteric longitudinal tenia, along with parts of the circular muscles projecting onto the area of excision (56). The authors of the method recommend starting the excision of the tenia about 5 cm proximal from the end of the intestine and continuing over a 20 cm distance. Results of several-year observations of 2 patients who underwent such surgery suggest that this surgical technique is promising, particularly in patients with short mesentery and a long, narrow pelvis. The value of this method is its simplicity and the low cost of the procedure.

Again, the question remains about the superiority of the techniques with fecal reservoir formation versus reconstruction with simple anastomosis. Results of oncological treatment in both groups are similar (29). Although researchers are unanimous in the evaluation of the quality of life of the patients, there is a dominant opinion that within a year from the opening of the anal passage, benefits are observed in patients with a fecal reservoir (17, 25, 29, 30, 38). This is important for patients with only a short expected survival (57). Although after the first year the benefits of this procedure seem to be less clear, most authors believe benefits extend up to two, three, five and more years of observation (17, 27, 28, 29, 40, 58, 59). The range of the observed benefits varies. It is commonly agreed that, over years of observation, fecal reservoirs contribute to a decreased number of bowel movements per day, and patients less frequently experience urgent defecations and nocturnal defecations. Compared to patients with simple anastomosis, they have better control over bowel and gas continence. In patients over 75 years of age, an increasing tendency for constipation was more frequently observed. There were no significant differences found between patients with and without a fecal reservoir with respect to the incidence of complications, such as a leak in the anastomosis or the in-anastomosis strictures. Similar results were obtained in evaluation of both groups for such parameters as duration of the surgery, morbidity and mortality (27, 29). Poor performance of simple anastomoses is believed to be caused by a too low pressure gradient between the neorectum and the anus. On the other hand, over the course of time in many patients with a fecal reservoir, the maximum tolerated volume of the neorectum increases, which may contribute to difficulty in de-
fecating. The resting pressure within the anus decreases more frequently in patients with fecal reservoirs (17, 29). Similarities in functional evaluation were noted, also following multi-annual observations, between patients with JP and those with CP as well as between those with JP and those with SE (27, 38, 47, 49, 53).

The objective of a decompression fistula is to provide protection to an anastomosis performed low within the pelvis. Authors emphasize that although the fistula may be the cause of complications, it markedly decreases the risk of a permanent loss of the capacity to defecate via the anus, particularly in patients undergoing emergency treatment. For this reason it is recommended that such a fistula is produced for a period of 6 weeks to 1 year; however the decision regarding its usefulness should be left to the discretion of the operating surgeon (60).

Methods to reconstruct the continuity of the digestive tract are still being improved on the basis of earlier observations and experience and thanks to the ongoing progress in medical sciences. New methods of oncological treatment and rehabilitation, utilization of increasingly sophisticated staplers for surgical procedures and the achievements of videosurgery, all promise further improvement of the quality of life of patients undergoing rectal resection in which the anus was spared and a fecal reservoir formed (7, 11, 61, 62, 63).

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