Low Anterior Resection

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Introduction

Low anterior resection (LAR) is a surgical technique applied for the resection of malignant and benign tumors located in the middle and low part of the rectum. The principals include of the technique mobilising the rectum, performing an anastomosis below the anterior peritoneal reflection and mobilising the splenic flexure.

Bowel Preparation

Infectious complications of colorectal surgery include wound infection, intra-abdominal or pelvic abscesses, and anastomotic leak. They are mainly caused by endogenous colonic cultures. It seems logical that reducing faecal load and the bacterial count in the intestinal lumen should reduce the rate of infections. Bowel preparation before surgery of the colon and rectum consists of mechanical bowel cleaning from residual stool mass and administration of pre-operative intravenous antibiotics. The essential aims are: comfort, assurance and clean environment in the operative field during surgery, reduction of intestinal flora and decrease in the rate of post-operative infectious events. When the colon is evacuated of stool mass, the amount of bacteria is decreased and mechanical disruption of the anastomosis by shaped, dense passing stool is possibly prevented. Each of the surgical centres usually uses their own methods of effective bowel preparation that have been tested over many years.

Mechanical bowel preparation is performed either by oral ingestion of cathartic agents or by enema irrigations. Historically, castor oil, anthroquinolones such as senna, diphenylmethanes such as bisacodyl, and salts such as sodium picosulphate and magnesium citrate in combination with a low residue diet and mannitol as an osmotic agent were used. At present, polyethylene glycol and sodium phosphate are most common. Polyethylene glycol provides a good quality of bowel cleansing from stool mass [1, 2]; it is popular and has well proven efficacy [3–5]. Intolerance resulting from a necessarily large volume of oral water intake (4 l) may appear occasionally in a group of patients. The symptoms include nausea, discomfort, vomiting, abdominal pain and distension [6, 7]. Sodium phosphate is equally effective with the benefit of no adverse events [7, 8], but causes a huge electrolyte imbalance, sodium phosphate should not be used in patients with chronic renal failure, cirrhosis of the liver, advanced heart failure and in patients with symptoms of ascites [9]. Patients tolerate sodium phosphate better but polyethylene glycol was proved to be safer.

During recent years a few studies have shown that colorectal surgery with no mechanical bowel preparation is equally safe and is not associated with higher rates of post-operative adverse events (wound infection, intra-abdominal abscesses, anastomotic leak) [10–13].

The Author uses mechanical bowel preparation with polyethylene glycol before each rectal resection. Despite many studies proving no benefits of bowel preparation, mechanical cleaning of the bowel makes the operation more comfortable for the surgeon, particularly during anastomosis formation. In connection with some unfavourable aspects resulting from mechanical bowel preparation, many surgeons asked if there is a need for pre-operative preparation.

In the past, bowel preparation consisted of administration of non-absorbable antibiotics to reduce the growth of endogenous colonic bacterial culture. For some years information referring to the efficacy of pre-operative bowel preparation has been inconsistent. Some studies demonstrated benefits of a pre-operative neomycin and erythromycin administered in combination, whereas several papers found them to have no effect [14–17]. Nowadays the application of those antibiotics has been given up.

Prophylactic use of pre-operative intravenous antibiotics is a standard procedure in all colorectal surgery. The efficacy of antibiotic infusion (most often second generation of cephalosporins and metronidazole) pre-operatively is well documented.
Unfavourable aspects of prophylactic use of antibiotics are the high costs of the application, the selection of severe and resistant bacterial cultures and also the risk of toxic colitis in the course of a Clostridium difficile infection [19].

**Surgical Technique of the TME**

Total mesorectal excision (TME) is a relatively new modification of the standard procedure of LAR. The technique was first described by Heald and Ryall [20] and became a widely accepted surgical standard in the treatment of cancer of the rectum. The principle of the procedure involves complete removal of the mesorectum and the mesentery containing the inferior mesenteric artery and vein. The method combines what seems impossible: oncological radicality and preservation of pelvic autonomic nerves. The key step of the procedure is the identification and consequent preservation of the pre-aortic superior hypogastric plexus as well as laterally located hypogastric nerves and sacral splanchnic nerves forming inferior hypogastric plexus on both sides of the pelvic wall.

The introduction of TME together with a high ligation of the inferior mesenteric artery and adequate distal margins of safety has led to a significant reduction in local recurrence rates as well as a reduction in bladder and sexual function impairment [21].

**Operative Procedure**

Surgery begins with the mobilisation of the left colon and sigmoid. The peritoneum over the lateral part of the descending colon and sigmoid colon has to be divided along the line of attachment of the peritoneum to the sigmoid colon mesentery. It can be best achieved by using electrocautery or sharp dissection with scissors. Careful preparation allows us to enter the avascular, alveolar space of the left iliac area with its structures: left urethra crossing iliac common artery and vein as well as iliopsoas muscle. At this point the descending colon and sigmoid can be gently mobilised and colonic vessels separated from the urethra. Identification of the left urethra is one of the crucial points of the operation because it can be easily injured while the operation advances. The incision of the peritoneum has to be extended downward to reach the posterolateral aspect of the left side of the pelvis. On the right side the division of the peritoneum has to be carried out over aorta and right posterolateral aspect of the pelvis. This incision should expose the origin of the inferior mesenteric artery and vein. The dissection and ligation of the mesenteric vein should be done first to prevent the spread of tumour cells into the bloodstream during manipulation of the rectum. The level of the dissection of the mesenteric artery is very important. The sympathetic trunks along the aorta send sympathetic nerves medially to the anterior surface of the abdominal aorta and form inferior mesenteric plexus at the level of inferior mesenteric artery. In order to prevent nerve damage, high ligation of the inferior mesenteric artery has to be done. The transection line should be roughly 1–2 cm distant from the aorta. This level represents also the cranial boundary of the mesentery lymph node package; lymph node metastases are rarely found at the point of origin of artery. After dissection of the mesentery vessels, pelvic dissection commences. The dissection should begin laterally and to the right of the promontory; at this point the identification of the avascular “holy plane” is best performed. Identification of the holy plane is a prerequisite for the surgical procedure. It should be done under direct vision and tearing of the mesorectum should be avoided. Below the aortic bifurcation, presacral sympathetic nerves form the superior hypogastric plexus, which is approximately at the level of the promontory. The plexus is covered with a thin layer of connective tissue and fat. The plexus then divides to form hypogastric nerves. The right and left hypogastric nerves run within the space between visceral pelvic fascia of the mesorectum and parietal pelvic fascia of the pelvic wall. The dissection has to proceed in the posterior plane between those two fascias. When the plane is identified correctly, the dissection goes through an avascular areolar space. It can be performed with the help of a waterjet device, electrocautery or sharp scissors. Blunt finger preparation should be avoided. Dissection in the posterior plane usually does not create any problem and can easily be continued till the tip of the coccyx (till the pelvic floor). Posterior dissection should be extended laterally. Dorsolateral dissection usually mobilises the rectum sufficiently to pull it out of the pelvis to some extent but it remains fixed to the pelvic wall on both sides laterally. Standard technique of LAR involves ligation of the lateral ligaments of the rectum; these structures are however small nerve branches and minor vessels arising from the branches of the internal iliac artery, which pass to the mesorectum through inferior hypogastric plexus. Preparation in the right plane and proper use of diathermy should eliminate bleeding from those structures. The “lateral ligaments” should not be clamped and ligated. When the lateral and posterior dissections are complete, the attempt should be made to start the anterior part. This is the most difficult part of the surgical procedure. Anterior rectal wall, posterior wall of the bladder, the prostate and semi-
nal vesicles or the posterior wall of the vagina originate from the same embryonic tissue, therefore there is no clear plane separating these structures. The peritoneum over the retrouterine or rectovesical pouch should be divided. In the male the anterior wall of the rectum is covered with the 0.5–1.0 cm layer of mesorectum, therefore incision of the peritoneal reflection should be done over the bladder in order to avoid entering the mesorectum. Great care has to be taken laterally dissecting the Denonvillier’s fascia where the inferior hypogastric plexus gives rise to the neurovascular bundle of Walsh which runs along the posterolateral aspect of the prostate. In the female the mesorectum is often very thin and therefore in direct contact with the posterior wall of the vagina. The crucial part of this part of the procedure is careful separation of the structures preferably with diathermy or water-jet in the plane between the Denonvillier’s fascia and seminal vesicles in male and posterior wall of the vagina in females. The dissection behind the fascia should be a natural continuation of the lateral dissection.

Following complete mobilisation of the rectum including mesorectum-free distal part of the intestine, the linear stapler is used to divide the rectum. Some Authors advocate the double-stapling technique.

**Damage to the Pelvic Autonomic Nerves**

Damage to hypogastric and splanchnic sacral nerves during conventional operations for rectal cancer result in very high rates of sexual dysfunction comprising up to 85% of surgery patients [22, 23]. Bladder dysfunction as reported by different Authors varied between 7% and 73% [24, 25]. What is equally important from the oncological radicality point of view are very low local recurrence rates, which are the result of an adequate removal of the tumour using the TME technique and have been reported by several Authors [26, 27].

Performing LAR, an end-to-end anastomosis between descending colon and rectum stump has to be performed. The distal margin should be a minimum of 2 cm; in low-grade tumours this distance can be smaller. A circular stapling device is used to create the anastomosis. Single- or double-stapling technique can be used. In the case of single stapler use, transection of the bowel is performed with a cutter. Purse-string clamps are placed on both proximal and distal stumps (Fig. 1). The anvil is inserted into a proximal stump. The circular stapler (without its anvil) is inserted transanally. After exteriorising the trocar, the purse-string is closed around its base. The last steps of the procedure include closing, firing and removing the stapler (Figs. 2, 3). But the most popular technique used worldwide is the double-stapled technique. This entails transection of the rectum distal to the tumour from within the abdomen using a linear stapling device (Fig. 4). The proximal resection margin is divided with a purse-string device. After sizing the lumen, the detached anvil of the circular stapler is inserted into the proximal margin and secured with the purse-string suture. The circular stapler is inserted carefully into the rectum, and the trocar is projected through or near the linear staple line. This is quite an important moment – the trocar
should pierce the anterior wall as close to the staple line as possible (Fig. 5). Then, the anvil is engaged with the trocar and, after completely closing the circular stapler, the device is fired. Two rings of staples create the anastomosis, and a circular rim or donut of tissue from the proximal and distal margins is removed with the stapling device (Fig. 6). The anastomotic leakage rate with this technique ranges from 3 to 11% for middle-third and upper-third anastomoses and to 20% for lower-third anastomoses. For this reason, some surgeons choose to protect the lower-third anastomosis by creating a temporary diverting stoma. This is especially important when patients have undergone a pre-operative RT course. A handsewn anastomosis may be performed; if preferred, the anastomosis is performed as a single-layer technique. Usually the handsewn technique is limited with the location of the tumor – if we really mean LAR, this procedure is usually possible only with stapling techniques. The leak and stenosis rates are the same for stapled and handsewn anastomoses.

Very low rectal cancers, located just above the sphincter occasionally can be resected without the need for a permanent colostomy. The procedure is as already described; however, the pelvic dissection is carried down to the level of the levator ani muscles from within the abdomen. A straight-tube colo-anal anastomosis (CAA) can be performed using the double-stapled technique, or a handsewn anastomosis can be performed transanally. This last option is also a rescue technique when we need to take down stapled CAA, due to some major leak during anastomosis testing. Some surgeons do not want to perform stapled CAA because of the possibility of implantation of malignant cells at the stapled transection line. The first stage of the procedure is to deliver descend-
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The best way to test the anastomosis after LAR is to place a 30 FR catheter through the anal sphincter and fill the pelvis with 0.9% saline. Then with a 250-ml syringe, insufflate the rectum with air; the bowel above the anastomosis is held by a noncrushing clamp. If anal anastomosis is checked, it is enough to place the syringe nozzle within the anastomotic area. In case of any doubt about anastomosis consistence, one or two sutures should be added into the site of the suspected leak, and after that the anastomosis should be rechecked. If there is still no evidence of complete anastomosis integrity, a proximal protective stoma should be performed.

Colonic Reservoirs

LARs due to cancer of the mid and low rectum can lead to functional impairments of sexual, urinary and continence dysfunctions. Low or very low end-to-end anastomosis using either stapled or handsewn technique enables gases and stool to collect, resulting in urgency and problems with continence, especially during the first year after surgery. Colonic reservoirs as options of “neorectum” are created to improve bowel function in patients undergoing LAR with CAA. “J-shaped” colonic and transverse coloplasty pouches are the available ways of restoring the neorectal reservoir [28].

J-Shaped Colonic Pouch

In 1986 a colonic J-pouch was described by Parc et al. [29] and by Lazorthes et al. [30], independently, to replace the excised rectal reservoir. The procedure comprises of identification of limbs with closed distal colon and seromuscular apposition. Long colotomy, closure of posterior and anterior wall may be performed using either conventional continuous suturing or a GIA stapling device with the final attachment colonic pouch to the anus with circular stapler. Ideal pouch dimensions are 6–7 cm of bowel circumference and with limb lengths about 5 cm. Most surgeons are of the crucial step of the procedure is mobilization of the splenic flexure of the colon and preserving the first branch of the inferior mesenteric artery to enable blood perfusion through the pouch [28]. Patients with colonic J-pouch may experience varying degrees of incomplete defecation requiring provoked evacuation with laxatives or daily enema use, unless J-pouch limbs are limited to a 5 cm size [31].

Inability to perform colonic J-pouch arises from some technical reasons, and therefore in about 25% of patients are unable to have a colonic J-pouch. Difficulties in creating a colonic J-pouch include:

• narrow pelvis (especially male patients)
• bulky colonic pouch
• long anal canal with prominent sphincters
• short fatty mesocolon
• diverticulosis
• insufficient colon length.

Benefits of colonic J-pouch are better rectal compliance and higher maximal tolerable rectal volume which can lead to improved rectal function after LAR [32, 33].

Transverse Coloplasty

A transverse coloplasty was first described (by Z’graggen) in 1999 and facilitate the construction of a pouch anal anastomosis. The pouch is performed by making an 8–10 cm longitudinal colotomy, 4–6 cm from the distal cut end of the colon. The colotomy is made on the antimesenteric side of the colon between the taenia. Colon is then sutured transversely with 3-0 polyglycolic acid seromuscular threads similarly to the Hainecken-Mikulicz plasty. Finally end-to-end stapled anastomosis is performed with CAA stapler [34].
Transverse coloplasty requires less space in the pelvic area than colonic J-pouch, therefore it is technically more suitable, especially in the narrow male pelvis. Short- and long-term follow-up show similar functional results of these two types of rectal pouches [35].

**Side-to-End Anastomosis**

The method of side-to-end anastomosis of the colon and rectum has been advocated to deal with the disparity between the two lumen. To create the modality the double-stapling approach can be used. Rectal stump is closed with a linear stapler. A proximal anvil is inserted in open sigmoid or descending colon and passed through the antimesenteric colonic wall. The end of distal colon is closed and the stapling completed in the usual manner [28, 36].

Rectal reservoirs should be considered, especially for anastomosis at or below 4 cm from anal verge. Traditionally a colonic J-pouch may be constructed if technically possible. Coloplasty seems to be an attractive modality to colonic J-pouch. Complications associated with the anastomosis do not differ in both groups, however colonic J-pouch patients with handsewn anastomosis had a higher anastomotic leakage rate than the patients in the coloplasty with handsewn anastomosis group [35].

Transverse coloplasty functional results are similar to those after colonic J-pouch construction and outcomes of both reservoirs are superior to straight end-to-end anastomosis [33, 35]. Colonic J-pouch and side-to-end anastomosis give comparable functional results two years after LAR [37].

However, long-term results show that there are no functional differences between described modalities and after a two-year post-operative follow-up study, quality of life outcomes also become similar. Thus, after this period, the presence of colonic reservoirs actually does not influence bowel habits or problems associated with so-called “low resection syndrome”, especially after straight anastomosis. They should be considered to diminish the functional impairment in the early post-operative period after very low rectal cancer.

**Lateral Lymphadenectomy**

Spread of rectal cancer via lymphatic vessels results in the involvement of lymph nodes, located both upward and lateral. Lymphatic vessels go from the lower rectum through the lateral ligament and reach iliac lymph nodes, so that lateral ligament is believed to be crucial in the lateral lymphatic flow [38]. Lateral lymphadenectomy is mainly practised in Japan. Lateral lymph nodes (middle rectal, obturator, internal iliac lymph nodes) are metastatic when tumours are located at or below the peritoneal reflection. The percentage of lateral lymph node involvement is assessed by many Authors on average as 9–18% and it ranges from 2.8% for T1 to 31–40% for T4 rectal tumours [39, 40]. All the Authors confirm that the percentage of lateral lymph metastases strictly depends on tumour growth. It was also observed that for the tumors with a lower margin above 6 cm from the dentate line, metastases in lateral lymph nodes occurred only in 0.6% of cases, while in tumours with lower margin below 5 cm above this line it ranged from 7.5% (for tumors between 4.1 and 5 cm) to 29.6% (for tumors between 0.1 and 1 cm). The main reason pelvic lymphadenectomy in rectal cancer (complete clearance of lateral lymphatic nodes) is performed is to improve survival and reduce local recurrence. However, retrospective studies conducted by many Authors confirmed no improvement in a 5-year survival rate in the patients in whom this procedure was performed when compared to the groups where conventional operations were conducted [39, 41, 42]. Moreover, it is highlighted that the risk of urinary and sexual dys-function linked with lateral lymphadenectomy is too high and outweighs the risk of local recurrence associated with the presence of potential metastases in lateral lymph nodes [42]. It is still unclear whether extended pelvic lymphadenectomy is an appropriate approach and it is very important to establish precise indications for carrying out this procedure.

**Protective Stoma**

Temporary loop ileostomy or colostomy after LAR is usually considered in order to protect either colo-anal or colorectal anastomosis.

Relative indications for creating protective stoma are:

- very low anastomosis (colo-anal)
- pelvic sepsis
- blood loss leading to chronic anaemia
- poor nutritional status
- obstruction
- perforation of the tumour
- pre-operative chemoradiotherapy
- other systemic diseases [28].

If there is any concern about the integrity of anastomosis, diverting stoma should be made, especially in the case of tension on the suture line.

If the patient has received pre-operative chemoradiotherapy, temporary ileo- or colostomy should be made to enable complete healing of the anastomosis [43].
It is generally believed that now when the stapled technique has been introduced and handsewn anastomosis performed less and less, diverting stoma is avoided more often. It is also believed but not well proven that mechanical suture offers greater confidence of anastomosis than a manual procedure.

Loop ileostomy seems to be easier to perform than transverse protective colostomy. Some Authors find colostomy associated with a higher risk of complications in contrast with others, suggesting that creating and closure of loop diverting ileostomy is safer [44, 45].

The morbidity of ileostomy and colostomy closure, unless decreased, remains an important issue [46]. Some Authors suggest closing the protective stoma during the same hospitalisation, 7 days after the resection. In my opinion, early closure is associated with higher risk of complications even including post-operative mortality. The interval between creation and closure of the stoma should be at least 6–8 weeks. Longer periods between these procedures correspond with better outcomes. Simple closure of the colostomy is safer than resection of the colon in order to close the stoma [43].

During closing of the colostomy, special emphasis should be put on the integrity of marginal artery as it can be the only vessel that supplies blood to the distal colon down to the anastomosis. The consequences of ligation of the vessel are obvious and result in necrosis of the distal colon after anterior resection of the rectum.

One of the most common complications of closure of the stoma (especially colostomy) is wound infection, however it may be avoided by delayed wound closure but with primary packing of gauze with aseptic solution. The secondary closure of the wound can be performed 3–4 days after the main closing procedure [28, 43].

The type of a protective stoma should be considered and individualised to the patient’s conditions. Both types of stoma carry a high complication rate with a considerable mortality rate. The interval between stoma construction and closure has substantial impact on social and economic status [47]. Closure of the stoma is not free from complications, including post-operative mortality, thus the decision of closing should be also made after careful consideration [44, 46].

**Drainage After LAR**

The principle of post-operative surgical drainage is to perform it when one expects a risk of fluid collection. In the case of LAR of the rectum, there are three potential benefits of drainage. First, it can be helpful in recognition of post-operative bleeding; second, it helps to detect anastomosis leakage; and third, it protects against fluid collecting in potentially contaminated region of anastomosis, thus preventing abscess formation [48]. However, drainage after anastomosis below the peritoneal reflection remains controversial and according to the literature, in most of these cases drainage is not performed.

There are very few randomised trials comparing prophylactic pelvic drainage vs. no drainage after LAR [49–51]. In all studies outcomes were measured by percentage of mortality and presence of clinical anastomotic leakage, as well as by radiological anastomotic dehiscence, wound infection, re-operation and extra abdominal complications. Statistically significant differences between measured items in the two groups of patients were not observed in any of these studies.

Similarly, the studies underscore the low sensitivity of drainage in detecting leakage and post-operative bleeding, questioning its supposed warning function. So far there is not sufficient evidence confirming that prophylactic drainage in elective LAR reduces rates of complications and prevents anastomosis.

Another controversial aspect is duration of the drainage. It ranges from 3 to 7 days. Some authors indicate the need for further trials on drainage duration, especially focusing on comparison of short-term drainage with no drainage and longer drainage [52, 53]. This has not yet been investigated.

In our department we routinely use two Redon drainages when low interior resection of rectum is performed. In most cases they are removed on the second day after the operation as we noticed that at this timepoint drains stop collecting fluid. In my opinion drains prevent fluid (blood) collection and abscess development in the area of anastomosis. In view of the literature data it is necessary to perform further investigations to confirm the prophylactic role (or its absence) of drainage after LAR.

**Radiotherapy**

Talking about colorectal cancer we must remember that although pathologically we consider adenocarcinoma of the colon and adenocarcinoma of the rectum as one disease, these two entities differ from each aspect: Anatomical differences in vascularisation, lymphatic drainage and absence of a visceral layer beneath perineal reflection result in different risks of local recurrence after curative intent surgery. In 1974, the problem of local recurrence after low resection of the rectum was described by Gunderson. It was observed that tumours located beneath 12 cm
from anal verge have a direct route of spreading in the pelvis via vessels, lymphatic system and directly via contact with surrounding tissues. With the introduction of TME, the rate of local failure dropped radically [54]. Still, local recurrence is a major problem in rectal tumor surgery. Neoadjuvant and adjuvant radiotherapy (RT) were introduced to decrease the rate of local failure.

Neoadjuvant Radiotherapy

There are many reasons for advocating pre-operative RT of advanced rectal cancers:
- reduction of local recurrence rate (better local control),
- reduction of tumour cells’ spread via pelvis in the course of surgery,
- reduction of cases of residual disease (microscopic disease),
- reduction of tumour stage (increasing the chance for sphincter-preserving surgery),
- reduction of tumour size and infiltration,
- lower morbidity in comparison to post-operative RT (especially connected with small bowel).

Other biological conditions supporting the role of pre-operative RT include higher level of oxygenising of tissues and sensitivity of tumour tissues to irradiation (no effect of ischaemic bed). The specific anatomical shape of mesorectum in pelvis results in a small circumferential margin when LAR is performed, which results in concerns about oncological clearance. Pre-operative RT improves this situation. The number of local recurrences is statistically lower with the use of pre-operative RT. In some cases the LAR is virtually possible because of RT.

In 1997, a Swedish trial showed a positive influence of pre-operative RT on life expectancy [55]. Unfortunately, no other trials have confirmed this conclusion. On the other hand there is a revolutionary paper describing 71 (28%) out of 260 patients with complete clinical response to pre-operative chemoradiotherapy who were not treated surgically [56].

It must be emphasised that precise estimation of tumor stage is the key to qualification for pre-operative RT. If the tumor is described as T1 or T2, surgery alone is standard. T3 tumors, short course pre-operative RT is advocated. Short course of RT comprises of total dose of 25 Gy, 5 Gy per fraction for 5 days and is given before consecutive surgery which follows 1 week after radiation. In case of T4 tumors, long course pre-operative RT should be introduced. The patient is irradiated 5 days/week for 5 weeks to the total dose of 45–50.4 Gy with 1.8 Gy per single fraction. It is mainly combined with 5-FU chemotherapy with (first and last week of irradiation). The surgery is performed 4–7 weeks after irradiation.

In the Uppsala trial in Sweden, adjuvant and neoadjuvant therapy were compared directly. The study revealed a significantly lower rate of local recurrence after the neoadjuvant mode of irradiation (12 vs. 21%) [57].

Although some authors suggest that in selected cases a sphincter-preserving operation could be performed because of the downstaging result of long course pre-operative RT [58], there is general agreement that the operation policy should not be changed after neoadjuvant therapy.

Beside the fact that more and more data are being gathered in favour of the pre-operative mode of irradiation, post-operative radiochemotherapy is still acceptable. It should be performed if post-operative pathological assessment reveals symptoms of cancer advancement. It is conducted in the following manner: radiation to the total dose of 45–50.4 Gy with 1.8 Gy per single fraction. The patient is irradiated 5 days/week for 5 weeks. It is combined with chemotherapy with 5 FU (6 courses, one week each; first and last week of radiation is combined with 3rd and 4th course of chemotherapy).

Talking about RT, we must remember about morbidity. Colitis, cystitis, wound healing problems and small bowel obstruction are the most frequent side effects of radiation. As LAR is performed more and more frequently, LAR syndrome is one of the most frequent side effects of RT which is worsened by RT (15% LAR alone vs. 30% LAR plus RT) [59, 60]. The goal is that both neoadjuvant courses seem to result in less frequent complications than post-operative RT [59, 61]. This provides another argument in favour of pre-operative RT.

Results of the Treatment

One of characteristics of rectal cancer is a predisposition to local recurrence and distant metastases. Evaluation and comparison of the results of treatment presented by various centres are not easy because of differences in number of patients, interpretation of various statistical methods, and in the first place – lack of standard criteria for qualification of the patients. Numerous prognostic factors affect survival rate: stage of the disease, tumour localisation, complications (bowel obstruction, tumour perforation, haemorrhage), tumour morphology, histological findings, mucous secretion and (recently brought into discussions more and more often) quality of treatment connected with the surgeon’s experience.

A modern surgical treatment of rectal cancer that leads to an improvement in results was introduced by
Dixon in the Mayo Clinic. In 1940 he performed partial anterior resection of rectum. A further improvement in the results of treatment was observed in 1977, when Turnbull introduced the “no-touch” isolation technique, which was the basis for the oncological aseptic technique during the operating procedure [62, 63]. The real revolution in surgical treatment was the introduction of the TME technique presented in 1980 by Heald et al. [64].

Studies comparing results of treatment utilising TME with the conventional technique clearly show benefits of the TME technique. Local recurrence rate in curative resection, during a 3–5-year period with TME is 3–11% [65–72] compared to 23–30% with the conventional technique [66, 68, 69]. Five-year survival rates after TME are 68–80%, and after conventional operations only 45% [73, 74]. Metastasis appearance is 23–25% after TME and 60–65% after conventional treatment. The above facts show the clear-cut position of TME as the golden standard in the treatment of rectal cancer. The next factor improving results of treatment of colorectal cancer is pre-operative RT, which is discussed separately.

We must remember that results presented are only average numbers, not taking into consideration various prognostic factors, which can influence results of the treatment of the rectal cancer. Basically, the most important and undisputed prognostic factor is the tumour stage, precisely described by the TNM system. Five-year survival rates in an analysed group of 15,000 patients were: stage I, 70%; II, 55%; III, 46%; and IV, 9% [75, 76]. Lymph node metastases as well as local cancer invasion in blood and lymphatic vessels cause further worsening of five-year survival. Positive resection margin always leads to the recurrence of the cancer.

Worse results of the treatment are usually described in younger patients, below 40 years of age [77–79]. An important fact is that in younger patients we are dealing with poorly differentiated and mucous secreting tumours more often. Other facts are the more aggressive and fast course of the disease and – unfortunately – late diagnosis, with large tumour and advanced stage of disease.

The influence of sex on survival remains uncertain. A statistically significant worsening of 5-year survival rate in men compared to women was observed in many studies [79–81]. But worse prognosis for men was observed mainly in Dukes B and C stages. Numerous recent studies do not show a significant influence of sex on survival rate or recurrence of the disease [82, 83].

Complications of rectal cancer, like bowel obstruction, hemorrhage or perforation, that usually are indications for immediate surgical treatment, correlate with crucial deterioration in treatment results. The complete 5-year survival rate is significantly lower, and cancer recurrences are more frequent than in uncomplicated cases. A worsening of the prognosis is connected with a low percentage of operative tumours, due to the advanced stage of the disease, as well as with the possibility of intraperitoneal spread of cancer cells, which have a capacity for implantation and growth [84, 85]. Another factor that affects results of treatment is an unintended tumour perforation during the scheduled operation of an uncomplicated tumour [86].

Histological grading of tumour has unquestionable influence on treatment results. Poorly differentiated tumours are characterised by aggressive and dynamic growth. This is connected with a significant decrease in survival rates [87], increased rate of total cancer recurrences [88] and local recurrences as well [78].

Tumour morphology is another factor that may affect recurrence prognosis. Raised tumours cause local recurrence less often than ulcerative tumours, coring into bowel wall [79]. The reason for this situation may be significantly lower cancer infiltration outside the bowel wall and lower rate of lymph node infiltration and distal metastases, in cases of rising type of growth tumours. Circular type of tumour growth is also connected with worsening of the prognosis [89]. Bad results are also proven in cases of mucous-secreting tumours [80], which appear in younger patients (less than 40 years) more often.

Recent studies show unquestionable influence of treatment quality and surgeon’s experience on the results of treatment. Low-volume hospitals have significantly lower survival rates compared to high-volume centres. Surgeons well experienced in pelvic surgical procedures, as well as in bowel resections, have better results, lower recurrence rates and better long-term survival rates [78, 90].

### Early and Late Complications After LAR

Anastomotic leakage has always been a major clinical problem in rectal or anal anastomosis, however this complication after LAR still remains a challenging clinical problem that can lead to significant morbidity and mortality. The use of stapling devices, performing mid and low rectal cancer resections with TME that require radical dissection may lead to a higher rate of anastomotic leakage. The reported clinical leakage rate after anterior resection varies from 3 to 21% depending on the level of anastomosis, the method of reconstruction and surgical expertise. The post-operative mortality associated with anastomotic complications ranges from 2 to 25%. On the other hand, the low local recurrence rate and
improved survival after TME supports the necessity of the removal of the entire mesorectum. A low level of anastomosis is usually regarded as the significant risk factor increasing anastomatic leakage rate. As reported by Vignali et al. out of 1014 stapled rectal anastomoses, the leakage rates were 7.7 and 1% from anastomoses at a level below and above 7 cm from anal verge, respectively. In the report by Law et al., age, level of the tumour, level of the anastomosis, concomitant resection of the other organs, stage of disease and the technique of anastomosis were not significant factors. They found the gender of the patients and the presence of a stoma were the most important and independent risk factors for anastomatic leakage. The difference may be explained by the anatomical differences of the pelvis between males and females and might only become significant when the anastomosis is performed at a low level. Leakage rate in men was 13.4% while that in women was 5.2% ($p=0.049$). The presence of a stoma was associated with a lower leakage rate. In the group with proximal diversion, the leakage rate was 4.8% while that of the group without diversion was 16.1% ($p=0.008$). Moreover, in the male patients, the leakage rates in those with and without proximal diversion were 5 and 27% respectively ($p=0.001$) and in the female patients the presence of a stoma had no effect of the anastomotic leakage rate. Therefore Law et al. recommend routine creation of a stoma in male patients.

However, the relationship between a diversion stoma and anastomotic leakage is more controversial. Many studies did not find a lower leakage rate in patients with proximal diversion. In patients with anastomotic leakage, both conservative and surgical options (diversion stoma, Hartmann’s procedure) may be considered. Conservative treatment for anastomotic leakage is usually possible in the presence of proximal diversion. Although the double stapling technique enables low rectal anastomoses, the transanal CAA still has its role. According to some surgeons, tumours at a level 2–3 cm from the dentate line were treated with transanal CA to preserve the anal sphincter. Enker et al. reported the low leakage rate in CAA after LAR in 1985. Law et al. did not find any statistical difference in leakage rate between double stapling and handsewn CAA. The low leakage rate of CAA may be due to the routine proximal diversion in the CAA. The anastomosis predictably forms a perfect circular lumen. The stenosis is almost always subclinical and associated with a lower leakage rate. In the group of stapled anastomoses, the leakage rates were 5 and 16% respectively ($p=0.001$) and in the female patients the presence of a stoma had no effect of the anastomotic leakage rate. Therefore Law et al. recommend routine creation of a stoma in male patients.

Stapled anastomosis besides its advantages is associated with the higher rate of anastomotic stenosis or stricture. The exact incidence of this complication is difficult to determine because the definition of stenosis is not well defined. Lett et al. and Fazio have defined a stricture as a narrowing that does not allow passage of a 15-mm sigmoidoscope. It is believed that, according to Kyzer and Gordon considered stenosis as any anastomosis that did not accept the 19-mm sigmoidoscope. The aetiology of anastomotic stenosis is not completely understood. When the colon is found to be ischaemic it may lead to further stricture above the anastomosis. It is proposed that stenosis may be caused by insufficient circulation in the marginal artery and this insufficiency may be aggravated also by irradiation. Experimental studies indicate that stapled anastomoses heal by second intention because the mucosa of the bowel segments is not in apposition but is separated by the muscular and serosal layers. Therefore, the precise stapled anastomosis predictably forms a perfect circular scar, which results in a narrowing of intestinal lumen. The stenosis is almost always subclinical and faecal dilatation ultimately provides for wide patient anastomosis [91, 94, 95]. Benign strictures arise in 5.8–20% of colorectal anastomoses. For such strictures, endoscopic dilation has proven to be a useful and safe treatment. Both through-the-scope balloon and over-the-wire pneumatic balloon dilation techniques are effective and safe for treatment of benign colorectal anastomotic strictures. Were et al. also reported good results after dilation of benign strictures following LAR using Savary-Gillard bougies [96, 97]. Yagyu et al. [98] found irregular finger dilation of the anastomosis to be useful for preventing anastomotic stenosis after LAR.

The role of temporary defunctioning stoma in patients undergoing LAR remains controversial. Grabham et al. [99] suggest that it should be performed in selective cases where there is a concern about the anastomosis due to difficult dissection, incomplete doughnuts and tension on anastomosis. Machado et al. [100] compared surgical outcome after LAR for rectal cancer with colonic J-pouch at two departments with a different policy regarding the use of a routine diverting stoma. A total of 161 patients with invasive rectal cancers were operated on between 1990 and 1997 with TME and a colonic J-pouch. Eighty patients were operated on in a surgical unit using routine defunctioning stomas (in 96%) whereas 81 were operated on in a department in which diversion was rarely used (5%). There was no difference between the two centres in post-operative mortality in connection with the primary resection and subsequent stoma reversal (3.7% vs. 3.8%). No significant difference could be found in the number of
patients with pelvic sepsis (anastomotic leak: 9 vs. 12%). According to this study, the routine use of diverting stoma does not protect the patient from anastomotic complications or pelvic sepsis and requires a second admission for closure.

Another interesting issue concerning LAR is small bowel obstruction as the impact of diversion ileostomy. Poon et al. [101] reviewed 214 patients who underwent LAR between 1993 and 1999 and were readmitted with the diagnosis of small bowel obstruction. Median follow-up was 39 months; 22 patients presented with 30 episodes of small bowel obstruction, and operations were necessary in nine patients (40.9%). Malignant obstruction occurred in two patients (10.3%). Obstruction within 6 weeks of surgery (including closure of stoma) occurred in 13 patients (6.1%). Early obstruction occurred at a higher incidence in those patients who had an ileostomy than in those who did not (9.1% vs. 2.9%, \( p = 0.048 \)). The Authors concluded that the presence of diversion ileostomy was associated with an increased incidence of early obstruction; therefore the use of loop ileostomy for proximal diversion should be further assessed.

The goals in the treatment of rectal cancer are cure, local control, and preservation of sphincter, sexual and bladder function. The complications and mortality rate in the setting of pre-operative chemoradiation have not been well defined. However, the results prompted the addition of adjuvant or neoadjuvant pelvic irradiation with or without chemotherapy to reduce local recurrence rates and improve survival rates. Pre-operative radiation therapy results in increased surgical complications and post-operative radiation therapy produces considerable short-term and long-term complications. Enker et al. assessed the pre-operative complications in association with pre-operative radiation. To determine the pre-operative morbidity rate associated with pre-operative radiation sequencing, patients receiving pre-operative chemoradiation were compared with those in the other groups (Pre-op RT \( n = 150 \); No Pre-op RT \( n = 531 \)). All 681 patients underwent LAR for resection of primary rectal cancer. The type of surgical resection was distinguished between LAR (75%) and LAR with CAA (25%). One third of the patients undergoing CAA were stapled, two thirds underwent perianal sutured anastomoses. The leakage rate was significantly higher in patients undergoing LAR than those undergoing CAA. A temporary diverting ileostomy or colostomy was performed in 214 (31%) patients. Of the patients with a diverting stoma, 122 (57%) had a CAA. The leakage rate was no different among those with diversion or those without. In addition, a diverting stoma did not reduce the incidence of anastomotic leak among those undergoing LAR without CAA. The operative time, estimated blood loss and rate of pelvic abscess formation without associated leak were higher in the Pre-op RT group than the No Pre-op RT group. However, the overall complication rate and incidence of wound infection, anastomotic leaks and pelvic abscess formation not associated with a leak were compared between patients who did and did not receive pre-operative chemoradiation. The incidence of pelvic abscess formation was significantly higher in those who received pre-operative chemoradiation. Because LAR is a clean-contaminated procedure, localized sepsis in the contaminated radiated field is not surprising. It would be of interest to evaluate the potential efficacy of a more prolonged antibiotic course in patients receiving pre-operative radiation [98]. Pucciarelli et al. reported that pre-operative combined RT and chemotherapy for rectal cancer did not affect early post-operative morbidity and mortality in LAR. They respectively compared 41 patients (Group A) with 30 patients (Group B) who in the same period underwent surgery without pre-operative adjuvant therapy. Minor post-operative complications that occurred in both groups (Group A - 51%, Group B - 62%) were anastomotic leak, middle and moderate anaemia, urinary tract infection, urinary retention, post-operative prolonged ileus, wound infection and bronchopneumonia. Major post-operative complications occurred in each group (\( p = \text{NS} \)). They were anastomotic leak, anastomotic haemorrhage, descending colonic necrosis, rectovaginal fistula, haemoperitoneum and necrosis of gastric curvature, pelvic abscess and high output from ileostomy requiring readmission. Anastomotic leaks were treated conservatively with no further morbidity or reoperation. Of the two patients with rectovaginal fistulas, one underwent ileostomy and the other, who already had a diverting stoma, was given conservative treatment. One patient with an anastomotic haemorrhage was given endoscopically guided sclerosin injections. Three patients required reoperation for post-operative complications: one cirrhotic patient underwent reoperation for necrosis of anastomosed colon; the second patient required surgery for massive bleeding from the sacral veins; and the third one for ischaemic necrosis of the greater gastric curvature requiring emergency gastric resection. Conservative treatment was given for the remaining two major complications: a para-anastomotic abscess and combined water and electrolyte deficit caused by the high output from the covering ileostomy. At multivariate analysis, ASA score 3, absence of diverting stoma, LAR with CAA, low pre-operative haemoglobin value and more intraoperative blood loss were found to be independent predictors of major complications. Whether pre-operative
adjuvant therapy influences early post-operative mortality and morbidity is still controversial. Most of the studies report morbidity and mortality after preoperative adjuvant RT alone. Some Authors have found significant peri-operative mortality or morbidity rates or both, although others have not [102].

The advent of surgical stapling devices has resulted in a dramatic reduction in the number of abdominoperineal resections, however, transanal stapled anastomosis may be associated with continence disturbances and reduced post-operative anal sphincter function. Disorders of continence are present in up to 60% of all patients who undergo LAR for rectal cancer. It is likely that an anal stretch type of mechanism is responsible for internal sphincter injury that is seen on ultrasound [103].

Although anastomatic staplers are common in surgical practice and they allow more extended, lower resections of the colorectum, complications associated with stapler use have been reported. Anastomotic stricture and leakage is the most common. A unique complication following stapler use is colovaginal fistula during LAR. The management of a post-operative rectovaginal fistula after LAR for rectal cancer is difficult and requires reconstruction of the anastomotic site and fistula. One of the reconstructive operations is the technique using the posterior approach through the vaginal lumen for a high rectal cancer. It is likely that an anal stretch type of mechanism is responsible for internal sphincter injury that is seen on ultrasound [103].

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References

57. Frykholm GJ, Glimelius B, Pahlman L (1993) Preoper-
ative or postoperative irradiation in adenocarcinoma of the rectum: final treatment results of a randomized trial and evaluation of late secondary effects. Dis Colon Rectum 36:564–572


