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# Single-Layer Sutures in Abdominal Cavity Surgery

**Authors' Contribution:**
**A** – Study Design
**B** – Data Collection
**C** – Statistical Analysis
**D** – Data Interpretation
**E** – Manuscript Preparation
**F** – Literature Search
**G** – Funds Collection

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**ABSTRACT:** The aim of our study was to evaluate of short-term outcomes of 4210 patients who underwent open abdominal surgery with used either single-layer, absorbable, or continuous sutures. Seromuscular anastomosis were presented (without mucosa). Fluid therapy: GDT and zero-balance GDT were also discussed. Anastomosis leakage developed in 6 patients. They were treated by creating a stoma. Simultaneously, septic shock was treated. Re-anastomoses were performed after some time and after sepsis was suppressed. Results of treatment with use of double-layer sutures, which was is use before 1978, were presented. Analysis of 536 patients treated at the same time was conducted and 53 patients with anastomosis leakage was identified. Out of this group, 2 patients survived. Based on the literature review, the methods for performing anastomosis. Attention was paid to the advantages of single layer over multi-layer sutures: effectiveness, simplicity and lower cost of treatment. The occurrence of mechanical ileus was less frequently observed since ceasing to employ peritoneoplasty, and preoperational preparation of gastrointestinal tract in patients had a beneficial influence on their postoperative course. Postoperative complications were discussed mainly based on additional examinations such as TC and MRI. The attention was focused on the importance of medical observation and clinical examination by an experienced surgeon in order to identify postoperative complications. Antibiotic treatment in cases of postoperative complications was presented, as well as fluid therapy: GDT, zero-balance GDT and the procedures employed in cases of complications such as: anastomosis leakage, mechanical ileus, inter-peritoneal abscess. Anastomotic stenosis was not observed in this group of patients.

**KEYWORDS:** complications, complications treatment, fluid therapy, one-layer suture, ways of performing

## LIST OF ABBREVIATIONS

**CT** – computer tomography
**GDT** – Goal-Directed Therapy
**NSAIDs** – nonsteroidal anti-inflammatory drugs
**POGS** – postoperative gastrointestinal stoma
**SIRS** – Systemic Inflammatory Response Syndrome

## INTRODUCTION

We would like to present experiments in the use of single-layer suture in abdominal surgery in the years 1986 to December 2016 in the Surgical and Urological Departments. The work presents the extremely important issue of using this type of suture as well as preventing, diagnosing and treating fistulas of intestine.

## MATERIALS AND METHODOLOGY

A total of 4,210 single-layer anastomoses was performed (Tab. I.). The age range of the patients treated ranged from 3 to 85 years, average: 69 years. 65% of the analysed material were male.

## METHOD OF IMPLEMENTATION

The anastomoses were performed with single or continuous sutures. They cannot be performed under tension, on ischemic intestinal elements; they must have the same diameter. In the case of a difference in diameter, the intestine was cut on the antimesenteric side, the complex sections were narrowed with single or continuous sutures. First a fragment of the intestine well-supplied with blood and provided with arterial and venous vessels was searched, and the division was performed in the mesentery with the least vascularization. When choosing poorly vascularized areas, an operating lamp works well; its light, when directed from the patient's head, makes the vessels visible when viewed from the antimesenteric side. We want to present above all intestinal anastomoses, which require special precision when complications threatening the health and life of the patient may occur in the postoperative course. The anastomoses were performed with single layer of absorbable sutures, including serosa and intestinal muscle membrane without mucosa. Directional sutures were applied on the mesenteric and antimesenteric side 2/0. Then, the lower sutures were turned upwards to perform mesenteric anastomosis. The posterior wall of the intestine was anastomosed; then, the directional sutures were

**Tab. I.** Types of surgery.

| NO. | TYPE OF SURGERY WITH SINGLE-LAYER SUTURE | NUMBER | % |
|---|---|---|---|
| 1. | Ureteral anastomoses | 1600 | 38,0 |
| 2. | Bladder sutures | 1100 | 26,1 |
| 3. | Cystectomies | 680 | 16,1 |
| 4. | Bladder neck-urethral anastomoses | 210 | 4,9 |
| 5. | Small intestine anastomoses | 250 | 5,9 |
| 6. | Urethro-intestinal anastomoses | 190 | 4,5 |
| 7. | Large intestine anastomoses | 110 | 2,6 |
| 8. | Gastro-intestinal anastomoses | 70 | 1,6 |


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inverted, and the anterior wall was anastomosed. 4/0 sutures were placed at a distance of 3–4 mm from each other and 4 to 9 mm from the edge of the intestine. They were serous-muscular sutures. It is extremely important that it is a single-layer suture. The impermeability of the anastomosis can be checked by massaging the walls of the intestine submerged under water at some distance from the anastomosis edge, observing whether there are any air bubbles passing through the anastomosis. Or – most practical – check them with the smallest Pean forceps: if the sharp tip does not pass through the anastomosis, then it is done correctly. If there are gas leaks, they can be stitched with 5/0 sutures. The edges of the cut mesentery were stitched with single sutures. They should be put on superficially. Mesenteric puncture can cause a large mesenteric hematoma, often very difficult to control, which destroys all effort put in the anastomosis. Anastomosis is a huge challenge for operators: it keeps them in tension that increases as the procedure progresses to the end of the anastomosis and a dozen or so days later – in fear of complications.

Single or continuous silk sutures were used for stitching, followed by: dexon, chromed ketgut, dexon, and polysorb. Single-layer sutures have been in use since 1978. Around the same time, the use of wall and visceral peritoneal sutures was discontinued. Peritoneoplasty of anastomoses was not performed, sometimes they were covered with a net. Since 1998, prior to cystectomies, gastrointestinal rinsing (wash out) with oral phosphate and antibiotic preparations (Neomycin, Tetracycline) was performed, which was then replaced with rinsing with Fortrans Cytra Fleet preparations. The coatings were closed with sutures without peritoneal suturing, the sheaths of straight muscles were sutured with 1.2 continuous slow absorption sutures. Sutures were applied through all layers, which were removed on day 6–8 after surgery. Drains around the anastomosis were removed in 4–6th day or when the amount of drainage has dropped to 100 ml. The patient was activated very early on (day 2). Fluid drinking was introduced early if there was no nausea or vomiting. After the return of peristalsis, feeding of the patient was implemented. Since the abandonment of peritoneoplasty and the implementation of gastrointestinal lavage, a much milder postoperative course has been observed (rapid peristalsis recovery, approximately 10% of patients required surgery to insert the probe into the stomach).

### Uretro-pelvic junction stricture. Anderson-Hynes procedure

After cutting out the excess from the "hockey stick" – shaped renal pelvis with the Anderson-Hynes method, and after narrowing the pelvis cross-sections with 2/0 continuous sutures, the ureter-pelvic anastomosis was performed with 4/0 absorbable sutures. First, the posterior wall of the anastomosis was exposed, reversing the directional stitches 180°. The anastomosis was performed after dissection of the medial side of the ureter within 3–4 cm outside the stenosis. The uretero-pelvic sutures should be applied very carefully, controlling the patency of the ureter with each application to avoid narrowing. The anastomoses were performed initially without catheter protection, and then left in the pelvis and the anastomosis was a Nelaton or DJ catheter with a diameter of 4 to 6 Ch, derived from a separate cut or into the bladder and removed after 3–4 weeks using a cystoscope. Nephrostomy was made. The drains were led through the posterior wall of the renal pelvis. Drainage of anastomosis, layered suturing of wound coatings. On the ninth day, after measuring the pressure in the renal pelvis, if no double-folded catheter was left in it, the pyelostomy was removed when the pressure was 15 cm water column. At high pressures, the pyelostomy was left and the amount of urine remaining in the renal pelvis was monitored. With persistent high pressure in the renal pelvis for more than three weeks, it is justified to apply retrograde ureteral splinting through a PIG-TAIL catheter for one month.

Sealed intestinal reservoirs require the emergence of a large segment of the intestine over 60 cm at a distance of 15 to 20 cm from the ileocecal valve. The antimesenteric edges of the intestine were cut, reducing intestinal pressure. The production of the reservoir usually involves the need for several anastomoses. The urinary reservoir was reconstructed using continuous serous-muscular sutures without mucosa, with 2/0 sutures being absorbed. The reservoir was connected to the urethra with 4, 5 or 6 sutures 2/0. A Foley 20 Ch catheter and, usually, suprapubic fistula were left in the bladder. Ureters were anastomosed with intestinal mucosa with 4/0 sutures on splinting catheters.

### Bricker's ileal conduit urinary diversion

The length of the intestinal loop was less than 20 cm. Ureters were implanted on the splinting catheters to the medial edge of the urethral fistula. The end was closed with 2/0 continuous sutures and the distal segment was being emerged onto the skin surface in the form of a urethral fistula. The gastrointestinal tract was reconstituted with 4/0 single sutures isoperistaltically.

The bladder was sutured with 2/0 continuous sutures without bladder mucosa. A catheter (most often Foley) was introduced through the urethra, usually a suprapubic cystostomy was performed. Bullous-tubular anastomoses, after radical prostatectomy, due to prostate cancer, were produced with 4, 5 or 6 sutures absorbed 2/0.

## TREATMENT RESULTS

**Tab. II.** Treatment results. Complications.

| NO. | TWO-LAYER SUTURE | NUMBERS | SINGLE-LAYER SUTURE SINCE 1986 R. |
|---|---|---|---|
| 1. | Treated | 536 | 4210 |
| 2. | Postoperative complications | 53 (100%) | 6 |
| 3. | Of those died | 51 | 0 |
| 4. | Of those survived | 2 | 100% |
| 5. | Mechanical ileus | 4 (without deaths) | _ |
| 6. | Out of the group of 53 postoperative stomas, around 4% survived | | 100% survived in the group of treated patients (0.25% re-operated) |

## COMPLICATIONS

53 anastomoses were found in the multilayer suture group. The average age of patients was 59 years. This group was heterogeneous. A common feature of patients with anastomosis dehiscence was a double layer anastomosis and postoperative intestinal fistulas. Two patients out of this group survived. Narrowing of anastomosis was found in 18 patients, most often undergoing conservative treatment. Anastomosis dehiscence was found in 6 people in the single-layer anastomosis

group. Patients were urgently re-operated while suppressing septic shock. Narrowing of the intestinal anastomosis was not observed.

## DISCUSSION

Gastrointestinal anastomoses are an indispensable element in gastroenterological surgery. It can be assumed that this is a permanent stage of elective and emergency surgeries. Although intestinal anastomoses are performed very often, there are no clearly defined rules for performing this type of surgery. We still assume that the choice of anastomosis technique should depend on the surgeon and their skills and habits. It is well established that when performing an intestinal end-to-end anastomosis, several things should be taken care of: its proper blood supply, lack of tension between the stumps and the appropriate geometry of the anastomosis, and in case of doubts regarding the healing of the anastomosis, a stoma should be performed. This conflicts with the principles of modern surgery. Today, the surgical community is proud to refer to data from clinical trials. It is believed that all clinical decisions should be based on reliable data from top-quality scientific research. Due to the multitude of constantly updated guidelines, which contain detailed information (often impractical from a clinical point of view) and precise recommendations on the type, scope and method of surgery, there is a lack of data on the technique of anastomosis, and thus the basic stage of each procedure.

The following types of anastomosis can be distinguished: single- or double-layered, single or continuous sutures, depending on the type of suture used: non-absorbable and slowly- or fast-absorbing, manual or mechanical sutures [1].

### Single or double-layer anastomosis?

The first intestinal anastomoses were performed almost 200 years ago. At the beginning of the 19th century, Lambert presented his experiments with the use of silk threads (non-absorbable) for gastrointestinal anastomoses. The technique was modified by Czerny, who proposed an anastomosis with two layers of single sutures, believing that the inner layer will allow adequate approach of mucous membrane and the outer layer will ensure good adhesion of the serous layer and additionally seal the anastomosis. For many years, this technique has been the "gold standard" and in many surgical centres it is still used today. Later, it was modified in various ways: the single sutures were replaced with a continuous suture, then the intestine was being fused, using only one layer of sutures. The use of a continuous single-layer suture was described by Hautefeuille in 1976, so 150 years after Lambert's experiments [2].

Studies on the advantages of a single-layer suture over a double-layer suture have shown that in the case of the former, anastomosis overgrows with micro-vessels as early as after 3 days, while the latter causes a more intense inflammatory response (after 2–3 weeks only tissue clumps were found) and significantly reduces circulation around the anastomosis. This is of course the result of introducing more allogenic material that causes reactions around the foreign body. Impaired blood supply is explained by the fact that to perform anastomosis with two layers, it is necessary to clean the walls of the intestine from the mesentery over a long section, which can impair blood supply. The key question is whether these observations from experimental studies in any way affect the clinical course and postoperative complications, especially the anastomotic leakage rates. A review of the literature with the Cochrane meta-analysis, which included seven randomized trials conducted in 1973–2000 involving a total of 842 patients, did not show the advantage of single-layer over double-layer anastomoses. There were no differences in the percentage of postoperative complications or the duration of hospitalization. The authors of the review noted, however, that anastomosis with one layer of sutures is performed faster and helps to reduce the duration of the procedure. It is also worth noting that the quality of the studies was moderate and included relatively few groups of patients. As Burch et al. showed, in order to clearly demonstrate a clinically significant difference in anastomotic leaks, a study involving at least 1,500 patients would be required. Studies suggest that serous-muscular anastomoses are safe and have a low percentage of complications [3, 4]. As you can easily imagine, examining such a large group of patients in one centre would be very difficult, if not impossible. In turn, multi-centre observation would be associated with the risk of introducing many disturbing variables (differences in anastomosis techniques, different experiences of operating surgeons, other perioperative care, etc.). To sum up: there is no clear evidence to justify the use of double-layer sutures, because single-layer anastomosis is associated with similar treatment results and given the shorter time of anastomosis and lower cost, it is a good alternative to traditional Lambert's technique.

### Type of suture material

Currently, Vicryl absorbable multifilament sutures (polyglactin 910) or more slowly absorbing PDS multifilament sutures (polydioxanone) are strongly preferred. It turns out that the severity of the inflammatory response is inversely proportional to the time of absorption. The largest was observed in anastomosis performed with fast-absorbing stitches. Some even believe that the degradation of absorbed sutures occurs too quickly, which adversely affects the strength of the anastomosis. There is no doubt that monofilament stitches cause less tissue damage and are therefore more often chosen for anastomoses performed with continuous sutures. Studies comparing different types of sutures were conducted many years earlier. They included very few groups of patients, preventing clear conclusions. It seems that the slowly absorbing monofilament suture is the most reasonable solution, due to several reasons: it reduces trauma during stitching, causes a smaller inflammatory reaction and is absorbed after a longer time (which is important e.g., in the case of Crohn's disease). We do not have good quality data from clinical trials justifying this type of statement [1, 5].

### Manual or mechanical (stapler) anastomoses?

There is no doubt that stapler anastomoses are more convenient, and in some clinical situations (e.g. ultra-low anterior resection of the rectum, oesophageal anastomosis following gastrectomy, most anastomoses after laparoscopic procedures), thanks to the use of a stapler, anastomosis is at all possible. The advantage of a mechanical anastomosis is a shorter duration. However, the cost is higher compared to a manual one. Probably for this reason, manual anastomosis is still preferred in our country (of course, excluding the special situations mentioned above). To date, many randomized trials have been carried out comparing the results of both techniques. Both anastomoses within the large intestine

as well as within the small and large intestine were analysed. In one review of colorectal anastomoses involving 1233 patients (9 randomized trials), Neutzling showed no difference in mortality, leak, narrowing, and reoperation rates between manual and mechanical suture. In turn, Choy et al. analysed the results of anastomoses following right hemicolectomy (7 randomized trials, 1,125 patients). Although the overall anastomotic leak rate was smaller in the stapler anastomosis group, this difference became insignificant when only symptomatic cases were included in the analysis. There were no differences between groups in the remaining endpoints. It turns out that using a stapler, although convenient (and often necessary), is associated with a greater risk of narrowing in follow-up. However, it seems that stapler anastomosis may be advantageous if a less experienced surgeon must perform it. As noted by Friend and colleagues, the percentage of anastomotic leaks was higher among patients after manual anastomosis in the subgroup of patients operated on by residents. To sum up: data on this topic allow for a reasonable statement that none of the methods has clinical advantage and the use of specific material for anastomoses should be decided by the surgeon, guided by the location of the anastomosis, their abilities, the patient's condition (especially if it is necessary to shorten the duration of surgery) and economic considerations. We are aware that not only the surgical technique, but also the perioperative procedure has changed in recent years, which may affect the results. However, if a configuration that seems the most reasonable must be chosen, then it is best to choose a slowly absorbing suture for anastomoses. Due to the shorter duration of the procedure and economic aspects, it is better to use a continuous suture. Stopping at one layer is safe and should not be associated with worse treatment results. It is better to do the anastomosis manually than with a stapler, but only in a convenient location. Otherwise, you can use the advancements of modern medicine.

To sum up, it can be said that the choice of anastomosis technique should largely depend on the surgeon, their skills and habits, so that they can always perform them in a perfect way.

## A comparison of triclosan with normal sutures

Sutures coated or impregnated with triclosan may reduce the incidence of postoperative wound infections. In vitro animal studies have shown that triclosan-coated sutures reduce bacterial adhesion, bacterial viability, and the secretion of pro-inflammatory cytokines that prevent post-operative wound infection. Stitches with triclosan should be used in 36 operated patients to prevent one infection of a postoperative wound. Patients in the group with triclosan sutures required revision of the wound less frequently, had fewer doctor visits, as well as were less often hospitalized and treated with antibacterial drugs, as compared to the control group. Technical progress limiting injury further reduces the number of complications. Absorbable monofilament sutures (Vicryl + monocryl, PDS) were used. The study used both multifibre and single-fibre sutures coated with triclosan and without an antibacterial coating. The study groups are numerous and authorize the authors to draw conclusions about the high effectiveness of the use of a chemical compound in the reduction of surgical site infections. The concentration of triclosan does not exceed 0.3%, and soluble sutures limit the exposure of the body to the components of the suture material [7].

## Perioperative fluid therapy

Intravenous fluid supply is an integral and life-saving element in the management of patients requiring surgical treatment. Hypovolemia results in perfusion disorders, reduction of oxygen delivered to organs and shock. Overhydration: leads to interstitial oedema and local inflammation, impairs collagen regeneration, which slows down the healing process and increases the risk of postoperative wound infection, wound dehiscence and anastomosis dehiscence. Overhydration impairs cardiovascular function [8, 9, 10, 11, 12, 13]. Strategies used during major operations to prevent it are: 0 Balance Therapy, i.e. restrictive strategy and GDT [8, 9, 10, 11, 12, 13].

## Leakage of anastomoses in surgery

POGS following surgery on the intestine is a leak or rupture of the anastomosis formed within the gastrointestinal tract with accompanying leakage outside the intestine, in the case of duodenal bile mixed with duodenal juice. The frequency of intestinal fistulas ranges between 0 to 4%, of duodenal – from 1.5 to 5.4%. Patients' mortality with external intestinal fistulas ranges from 10 to 15%, so it is extremely important to properly manage systemic disorders resulting from this complication. It is also extremely important to know the specifics of technical problems associated with the treatment of individual types of fistulas. The three main causes of complications and deaths in patients with intestinal fistula are: electrolyte disturbances, malnutrition and infections. Electrolyte disturbances mainly depend on the location of the fistula and its size, determined on the basis of the amount of content flowing from it. Low-secreting fistula – if less than 200 ml of content is discharged through it daily, medium-secreting – with 200 to 500 ml of secretions, high-secreting – if more than 500 ml of content flows per day. The type of electrolyte disturbance depends on the location of the fistula. Most often there is a loss of potassium, sodium, magnesium, bicarbonate and zinc. Appropriate supplementation of electrolyte deficiencies can prevent the occurrence of arrhythmias (hypokalaemia, hypomagnesemia), mental disorders (hyponatraemia) and acid-base balance disorders. Anastomotic fistula can be suspected if: pus or intestinal contents are secreted through the drain, paralytic obstruction persists, the patient feels abdominal pain, the patient does not defecate, there is fever, leukocytosis, increase in CRP and procalcitonin level. Cardio-respiratory disorders are found within 7–10 days after surgery. Leakage indicating fistula should be confirmed clinically or by radiological examination. The most accurate test seems to be using an aqueous shading agent containing iodine compounds. Confirmation of the presence of a fistula is its leakage outside the gastrointestinal tract into the peritoneal cavity or retroperitoneal space. The indirect symptom is the presence of free fluid and gas in the peritoneal cavity. The most common causes are: technical error (improper anastomosis, as a consequence of its leakage), anastomotic ischemia due to disturbance of blood supply to the anastomosis area, formation of anastomosis under tension due to incorrect assessment of the intestinal loop mobility, incorrect arrangement of the mucosal layer (mucosal interposition), intra-abdominal abscess (most often an external fistula is formed in this mechanism).

Anastomosis is favoured by intestinal obstruction below the anastomosis, disseminated neoplastic process, Leśniowski-Crohn disease, post-radiation condition, severe acute pancreatitis.

In order to reduce the risk of intestinal fistula formation during surgery: apply the principle of gentle preparation, prevent damage to the intestinal walls, avoid anastomosis, avoid anastomosis within the ischemic sections of the intestine, avoid contamination of the peritoneal cavity (rinsing the peritoneal cavity before closing). Malnourished patients with hypoalbuminemia, anaemia, and in poor general condition cannot be qualified for elective surgery. Patients from these groups should be operated upon prior preparation. The advantage of manual over mechanical suturing (stapler) or the advantage of single over continuous sutures or vice versa has not been demonstrated [14]. If the fistula occurred up to 72 hours after the operation, it is most often caused by a technical error, if later it is rather the result of anastomotic blood supply disorders [14].

## Leakage of anastomoses in colorectal surgery

Particular attention to operational risk factors should be paid before deciding whether anastomosis can be performed safely or there is a need for a decompressing or permanent stoma. Risk factors for anastomotic leakage can be divided into modifiable and non-modifiable. Modifiable factors: alcohol – consumption over 105 g per week, nicotinism – smoking over 40 packs of cigarettes per year, obesity – measures of abdominal obesity (waist circumference or index expressed by the ratio of waist circumference to hip circumference – waist hip ratio) is better than the body mass index itself. Anastomotic leakage is greater in patients undergoing organ transplantation, especially kidney transplantation, which is associated with taking immunosuppressants, such as mycophenolate mofetil, cyclosporine A, tacrolimus, everolimus, nitrapyrin, long-term use of corticosteroids, bevacizumab (vascular endothelial growth factor inhibitor). It is recommended to stop taking the above-mentioned drugs 28 days before the surgery. Malnutrition (loss of more than 10% of body weight over 6 months), hypoalbuminaemia <35g/L increase the risk of anastomotic leaks. Often, the cause of hypoalbuminaemia is not malnutrition, but sepsis, necrosis, or tumour perforation. Prior to surgery, measures should be implemented to improve nutritional status, as well as to treat other causes of hypoalbuminaemia. If it is not possible to compensate for significant malnutrition (unintentional loss of more than 10% of body weight and hypoalbuminaemia <32 g/L), then surgical tactics should be adopted to avoid anastomosis, if possible.

Mechanical bowel preparation is a burdensome procedure for patients. The Greccar III study showed a reduction in the risk of septic complications in patients operated on after mechanical bowel preparation; no differences were found in the frequency of anastomotic leaks. Radiotherapy – especially in the pelvis (in history) – is associated with an increased risk of pelvic anastomosis leakage.

## Antibiotics and selective gastrointestinal decontamination

Intravenous administration of a broad-spectrum antibiotic is a routine procedure in colorectal surgery for both elective and emergency surgery. The goal is to reduce infectious complications in the postoperative period. Oral antibiotics that are not absorbed from the gastrointestinal tract (tobramycin, amphotericin B) are administered. Selective decontamination has been shown to reduce the risk of anastomotic leaks from 7.4% to 3.3%. Similar conclusions were drawn based on the results of 8,000 colon surgeries. There were fewer surgical site infections and anastomotic leaks in patients undergoing decontamination.

Non-modifiable factors: male gender and age over 65 may increase the risk of anastomotic leakage.

The effect of age on anastomotic leak has not been confirmed in all reports. It is probably associated with comorbidities. Data for an increased risk of anastomotic leaks in patients with diabetes are contradictory. Diabetes has been shown to increase perioperative mortality and the duration of hospitalization. A higher incidence of perioperative complications is also associated with diabetic complications, such as diabetic angiopathy, including cerebral vessels, diabetic nephropathy, and cardiovascular disease. The authors of the guidelines recommend optimal treatment of diabetes in the perioperative period. It has been shown that the risk of anastomotic leakage is greater in patients with lung, vascular, renal failure, immunosuppression, after organ transplantation. Perioperative haemodialysis reduces the risk of overall surgical complications but does not affect the risk of anastomotic leaks. Patients with an ASA score above 2 also have an increased risk of anastomotic leakage [15].

## Elective and ad hoc procedures

Scheduled procedures generate a lower risk of anastomotic leaks. Urgent operations are not an absolute contraindication to anastomosis, as many studies have shown that anastomosis with decompressing stoma is a safe procedure for patients with intestinal perforation following diverticulitis. When considering anastomosis and decompressing stoma, factors such as hemodynamic instability of the patient, shock, hypoalbuminaemia, and the need to administer medications that constrict blood vessels should be taken into account. The benefits and risks of primary anastomosis and alternative treatments should be discussed with the patient before surgery.

## Factors associated with tumour

Distal anastomoses, especially in the rectal area, below the peritoneal fold, have a higher risk of leakage. The distance from the anorectal junction is an independent risk factor for anastomotic leakage. Other factors that increase the risk of leaks are a tumour larger than 3 cm, a locally advanced tumour, and distant metastases. Many risk factors can be related to each other, e.g. a patient with diagnosed late, advanced cancer usually has low socioeconomic status, malnutrition, nicotinism and numerous comorbidities.

## Procedure during surgery, surgical technique

Incorrect surgical technique (e.g. live anastomosis, insufficient vascularization of the anastomosis) negatively affects the healing of the anastomosis and may result in leaks. Other factors increasing the risk of leaks are surgery duration over 4 hours, contamination of the surgical field, loss of over 100 ml of blood, blood transfusion, hypoxia. The need for vasoconstrictor medication is associated with a three-fold greater risk of anastomotic leakage.

## Other management

The risk of leakage may also be reduced by anastomosis tightness tests, low rather than high vascular pedicle ligation, open and not laparoscopic surgery. All anastomoses within the rectum (all anastomoses within the left half of the colon), provided that no

decompressing stoma is performed, were routinely examined for technical defects by air insufflation.

### Decompressing stoma or omentoplasty

Using these techniques to seal the anastomosis can reduce the negative consequences of leaks, however they do not reduce the risk of anastomosis leaks alone. In colorectal surgery, drains were used to identify and reduce postoperative complications. Extensive systematic reviews – the Cochrane review – have not indicated that their use is associated with a lower risk of leakage. It should be emphasized that drainage is not required for small intestine and colon anastomoses. To assess its value in the case of low anastomoses within the rectum, a randomized clinical trial with appropriate statistical power is required. The decision to leave the drain in such circumstances remains the personal choice of the surgeon.

## POST-OPERATIVE PERIOD

### NSAIDs nonsteroidal anti-inflammatory drugs

An increasing number of reports indicate caution in the use of NSAIDs in the postoperative period. The meta-analysis showed that the administration of non-selective NSAIDs was associated with an increased risk of anastomotic leakage.

### Diagnosis of anastomotic leaks

Rapid diagnosis of anastomotic leaks is essential for successful therapy. Delayed leak detection is associated with worse treatment results. Clinicians must be alert to early and subtle signs of anastomotic leaks, also non-characteristic ones such as arrhythmias (including atrial fibrillation). Postoperative paralytic obstruction is not typical following colorectal surgeries. Its occurrence prompts the assessment of the patient's condition in terms of anastomotic leaks. Bleeding from the anus or passing mucus with a stool should increase vigilance regarding possible leakage of the anastomosis in the rectum. It should be emphasized that any deviation from the anticipated postoperative course in every patient with colorectal anastomosis must raise suspicion of anastomotic leak. In the event of deviations from the normal postoperative course, the most valuable way to diagnose leaks early is the repetitive assessment of the patient's condition by an experienced clinician. No surgeon can remain fully objective when he or she have performed the anastomosis. In this case, the opinion of a physician with similar clinical experience is particularly valuable. Increased levels of C-reactive protein (CRP) and procalcitonin are helpful (but they are not characteristic markers of anastomotic leak), especially when the first of these parameters reaches a very high value (CRP>150 ml/L between the 3rd and 5th postoperative day) and when the albumin concentration decreases or does not reach normalization in the postoperative period. The predictive value of a negative CRP result (i.e. normal CRP concentration) in this context may be particularly useful. Unlike CRP, white blood cell concentration is a less reliable measure of anastomotic leakage. Imaging tests do not play a significant role when the patient's condition is bad, and leakage is obvious in the clinical assessment. In such circumstances, diagnostic imaging can only lead to a delay in proper treatment. Commonly performed procedures such as CT, rectal infusion of a water-soluble contrast agent depends on the time of the test, the technical quality of the equipment and the experience of the radiologist. Diagnostic accuracy of CT performed due to suspected anastomotic leak in the distal colon can be increased by rectal and intravenous contrast administration. Imaging tests should not be performed on a hemodynamically unstable patient, unless it is possible to provide care by the intensive care unit which can implement immediate support for the circulatory and respiratory system. Contrast should be administered intravenously with caution in dehydrated patients with low blood pressure and acute kidney damage, or not administered at all.

### Anastomotic leak treatment

Pre-treatment: Efforts are being made in many countries to improve the effectiveness of sepsis treatment, which remains the leading cause of complications and mortality associated with anastomotic leakage. The definitions contained in this position correspond to the definitions referred to as: sepsis 1, sepsis 2 (SIRS), sepsis (SIRS + infection), severe sepsis, septic shock. Severe sepsis basically corresponds to the new definition of sepsis 3, i.e. life-threatening organ dysfunction caused by inappropriate, unregulated response of the body to infection (new sepsis is formerly severe sepsis). Definition of septic shock formerly in the sense that, according to sepsis 3, patients in septic shock are a group of patients with sepsis whose circulatory and metabolic disorders are so severe that they significantly increase mortality rates. Early, appropriate intervention should be considered obligatory if the patient develops sepsis as a consequence of anastomotic leak. The authors of Polish reviews recommend 4 basic elements of the procedure defined and introduced in the early 70s, i.e. hypovolemia correction, abscesses drainage, fistula secretion control and skin protection, which allowed the reduction of mortality rates to 12–30%. A breakthrough in the treatment of patients with gastrointestinal fistulae was the introduction of total parenteral nutrition and the creation of intensive care units. Following the introduction of the described assumptions, a 6.5% mortality rate was observed in a group of 61 patients with fistulas, according to 1973 publications [16].

### Final proceedings – general principles

Proceedings require careful assessment of the patient's hemodynamic status. If it is stable, initially conservative treatment may be employed, i.e. fluid-antibiotic-oxygen therapy and careful clinical observation. A patient with severe sepsis or septic shock requires urgent action to control the source of infection. A patient with anastomotic leak should be hospitalized in conditions appropriate to the severity of the systemic disease and allowing for his or her condition to be monitored. The optimal time for surgical intervention depends on the severity of the sepsis. If there is no organ failure, surgical or radiological intervention should be performed as soon as possible, but always within 18 hours of diagnosis. The purpose of this intervention is to control the source of the infection. If organ failure has occurred, intervention to control the source of infection should be carried out as soon as possible, but always within 6 hours of diagnosis. In the event of septic shock, you must immediately attempt to control the source of the infection – to prevent death, no later than within 3 hours. Controlling the source of infection associated with anastomotic leak may not be necessary in some cases. This applies to stable patients, in good general condition, without sepsis, who may have localized abdominal pain, increased inflammatory markers (gastrointestinal disorders, e.g. diarrhoea or paralytic obstruction). Imaging tests do not usually indicate an interruption of anastomosis but show a small fluid reservoir in the anasto-

mosis area (which is the clinical equivalent of anastomotic leak in this case). Complete relief of symptoms can be obtained in most cases by conservative treatment, which includes intravenous administration of antibiotics, exclusion of oral and enteral diets (only clear oral fluids allowed, parenteral nutrition) and close monitoring for signs of sepsis. In the case of small, limited anastomotic leakage in a hemodynamically stable patient, without radiological signs of interruption of the anastomosis, the treatment may consist of: drainage under imaging control, rinsing and the formation of a decompressing stoma instead of separating the anastomosis and creating stoma, provided that the patient is provided intensive care and signs of clinical improvement are visible. Drainage under radiological control should not be performed if imaging tests indicate complete separation of the anastomosis, and thus the leak is adequate, sepsis source control, healing of the anastomosis, numerous foci of intra-abdominal leakage related infection, are not suitable for percutaneous drainage; in such cases, laparotomy is necessary. Drainage through the rectum can be effective in cases of low rectal anastomosis leaks. Endoscopic introduction of vacuum dressings in the hypothalamic region, e.g. Endo-Sponge, may also be beneficial. The development of sepsis or the severity of septic disorders in patients treated conservatively or with drainage should be considered a treatment failure. The patient requires urgent re-operation and separation of the anastomosis. In cases of severe sepsis or septic shock in people requiring immunosuppressive drugs and those with significant albuminemia (below 32g/L), the repair should not be attempted. Similarly, the repair of the anastomosis should not be performed if an abscess has formed in its place. Proper healing in such circumstances seems unlikely, and a stoma is the safe solution. Any enterotomy – in most cases, it is unintentional damage to the intestine. If the anastomosis leaks, it may result in a creation of another source of peritoneal contamination. In that case, restoring enteral nutrition is impossible. Staple resection is recommended to identify the damaged section. Operating a patient with anastomotic leak not only requires technical skills but can also be emotionally difficult for the surgeon who performed the anastomosis. Feelings of guilt may prevent him or her from making objective decisions. It is recommended that another specialist be present during the re-operation who will impartially assess the situation in the operational field.

### Leakage of anastomosis outside the peritoneal cavity

The largest percentage of anastomotic leaks relates to anastomosis in the pelvis, outside the peritoneal cavity. The clinical manifestations of this type of leak may be subtler as there is no peritoneal contamination and most patients have a decompressing stoma. Treatment depends on the patient's condition. Separation of the anastomosis is recommended for all individuals with severe sepsis or septic shock due to the separation of the retroperitoneal anastomosis.

## SUMMARY

Up to the 20th century, gastrointestinal fistula amounted to death. In the first two scientific reports about gastrointestinal fistulas published in the world literature at the beginning of the last century, the mortality rate was almost 100%. In the 1960s, the mortality rate was 44%. The use of antibiotics did not improve the treatment results of this type of fistula.

### Complications and mortality associated with radical cystectomies

The first clinical observations in terms of complications and mortality associated with radical cystectomy were disappointing. The lack of widespread recognition for this type of surgery was attributed to a significant percentage of complications and the need to improve urine drainage techniques. Prior to 1970, the percentage of perioperative complications for radical cystectomy was approximately 35%, with mortality rates reaching almost 20%. Modern medicine and the latest surgical and anaesthesiologic techniques, as well as better patient selection, have significantly reduced mortality and complication rates. It is currently around 3% [17].

Since 1986, 4,200 patients have been treated with a single-layer suture. There were no deaths. Statistical comparison of the presented material is difficult due to the heterogeneity of the treatment groups.

Single-layer continuous and single sutures, correctly fitted, are a cheap, safe method of intestinal fusion and other abdominal surgery. For anastomoses, it is best to choose a slowly absorbing suture. The anastomosis is better when done manually, but only if the location is convenient. The choice of anastomosis technique should largely depend on the surgeon and their skills and habits, so that they can always perform them in a perfect way. It was emphasized in the paper that perfect management of the patient in the pre- and post-operative period and intensive treatment of post-operative complications has an impact on the results of treatment.

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