The Association of Polish Surgeons (APS) clinical guidelines for the use of laparoscopy in the management of abdominal emergencies. Part I

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Abstract

Introduction: *Over the past three decades, almost every type of abdominal surgery has been performed and refined using the laparoscopic technique. Surgeons are applying it for more procedures, which not so long ago were performed only in the classical way. The position of laparoscopic surgery is therefore well established, and in many operations it is currently the recommended and dominant method.*

Aim: *The aim of the preparation of these guidelines was to concisely summarize the current knowledge on laparoscopy in acute abdominal diseases for the purposes of the continuous training of surgeons and to create a reference for opinions.*

Material and methods: *The development of these recommendations is based on a review of the available literature from the PubMed, Medline, EMBASE and Cochrane Library databases from 1985 to 2022, with particular emphasis on systematic reviews and clinical recommendations of recognized scientific societies. Recommendations were formulated in a directive form and evaluated by a group of experts using the Delphi method.*

Results and conclusions: *There are 63 recommendations divided into 12 sections: diagnostic laparoscopy, perforated ulcer, acute pancreatitis, incarcerated hernia, acute cholecystitis, acute appendicitis, acute mesenteric ischemia, abdominal trauma, bowel obstruction, diverticulitis, laparoscopy in pregnancy, and postoperative complications requiring emergency surgery. Each recommendation was supported by scientific evidence and supplemented with expert comments. The guidelines were created on the initiative of the Videosurgery Chapter of the Association of*

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Polish Surgeons and are recommended by the national consultant in the field of general surgery. The first part of the guidelines covers 5 sections and the following challenges for surgical practice: diagnostic laparoscopy, perforated ulcer, acute pancreatitis, incarcerated hernia and acute cholecystitis. Contraindications for laparoscopy and the ERAS program are discussed.

Key words: *acute abdomen, laparoscopy, guidelines, evidence based medicine.*

Introduction

The idea of medical intervention inside the human body through the so-called "keyhole" has existed in medicine for over 100 years. In 1901, Georg Kelling performed the first successful, yet still experimental, diagnostic laparoscopic procedure (from Greek λαπάρα (lapára – side) and σκοπέω (skopéō – see)) on a dog. Nine years later, the Swedish thoracic surgeon Hans Christian Jacobaeus performed the first human thoracoscopy using a cystoscope, later finding that it was a good technique for diagnostics in various serous cavities. Polish medicine joined these pioneering procedures in 1928 thanks to Kazimierz Dąbrowski, who applied the Swedish surgeon's idea in clinical practice, diagnosing various liver diseases. However, the true beginnings of modern laparoscopic surgery should be sought only in 1980, when the German gynecologist Kurt Semm informed the world about the first appendectomy performed using a laparoscope he had designed. Unfortunately, initially his achievement turned out to be too revolutionary and, as a result, was considered by the medical community as unethical. The German Surgical Society then filed a motion to deprive Semm of the right to practice his profession. Not discouraged by the initial lack of acceptance, the author of the pioneering procedure performed several gynecological procedures using his own technique and instruments, proving their clinical value, and included his experience in very extensive literature later commonly used to learn this surgical technique.

On September 12, 1985, at a time when Semm's technique was already accepted by the surgical community, the German surgeon Erich Mühe performed the first cholecystectomy using a modified rectoscope, called a galloscope. This procedure is considered the beginning of the era of modern laparoscopic surgery and its rapid technological development. Already 2 years later, Phillip Mouret from Lyon performed this procedure using a videoscopic track, setting the direction of development of this technique to this day [1–3].

In Poland, the first laparoscopic procedure (cholecystectomy) was performed on May 15, 1991 in Poznań by Jacques Domerque, assisted by Marian Smoczkiewicz and Andrzej Dryjas [4]. Subsequently, the treatments were carried out by Przemysław Pyda and, on June 20, Marek Krawczyk. In the same year, laparoscopic cholecystectomies were reported from 4 Polish centers (a total of 219 operations), and 5 years later, national statistics recorded over 14,000 of these procedures. In 1991–1992, further operations were performed in Poland: appendectomy (Andrzej Modrzejewski), TAPP hernioplasty (Aleksander Stanek), fundoplication (Edward Stanowski) and excision of liver metastasis (Edward Stanowski), demonstrating that the laparoscopic technique has huge potential for clinical use.

Over the past three decades, almost every type of abdominal surgery has been performed and refined laparoscopically. Surgeons are still reaching for more operations that were previously thought to be performed only in a classical way. The position of laparoscopic surgery was thus established, and in many cases, it is currently the recommended and dominant method. The benefits of using this surgical approach are numerous and include reduced surgical trauma, better visualization of the operative site, reduced postoperative pain and the risk of postoperative wound infection, faster recovery of the patient and, consequently, shorter hospital stay, lower risk of scar hernia and symptomatic adhesions postoperatively. Considering the advantages of laparoscopy in a more detailed aspect, it is worth emphasizing the reduced risk of both intraoperative and postoperative bleeding, and thus the need for blood transfusion. The aforementioned advantages of minimally invasive access also translate into a better economic effect of the entire treatment and convalescence of patients treated with this method [5, 6].

Laparoscopic access allows for small surgical incisions, which is particularly important in the context of the risk of wound infection in the group of patients with morbid obesity, where the additional benefit of

laparoscopy will be significantly better exposure of the surgical site compared to classical access.

Laparoscopy can also be used as a diagnostic tool when other non-invasive methods have failed. Thanks to minimally invasive access, it is possible to collect material for additional examinations or finally establish the diagnosis, including in cases of penetrating abdominal injuries [7].

Currently, consideration of laparoscopic access should be an integral part of the decision-making process for emergency surgery for all abdominal pathologies [8].

Methodology

In preparing this study, the authors conducted a thorough analysis of the current literature on the management of acute surgical conditions. The summary was made through an extensive review of research from the last decades. The main goal was to select the current knowledge on the possibility of using the laparoscopic technique [9–13].

The development of these recommendations is based on a review of the available literature from the PubMed, Medline, EMBASE and Cochrane Library databases from 1985–2022, with particular emphasis on systematic reviews and clinical recommendations of recognized scientific societies and monographs [14]. Reference was made to the positions of recognized scientific societies, in particular EAES and SAGES, adapting them to the Polish health care system. A total of 388 publications were selected and analyzed and used to support the recommendations. The recommendations are general and require individual analysis and adaptation to a given clinical situation.

The process of creating recommendations was planned and carried out in the following stages:

1. Development of the document process and plan, identification and invitation of experts (J. Sobocki, M. Pędziwiatr),
2. Literature review and draft recommendations with comments (all authors),
3. Draft wording (all authors),
4. Correction of the draft version and preparation of the version for evaluation (J. Sobocki, A. Obcowska-Hamerska),
5. Evaluation and submitting corrections (J. Sobocki, M. Pędziwiatr, W. Hołówko, P. Major, K. Mitura, P. Myśliwiec, M. Orłowski, J. Szeliga, M. Zawadzki),
6. Wording of the revised document (all authors),
7. Reassessing and submitting corrections using the Delphi method (TCHP Expert Group),
8. Formulation of the final version of the document (all authors).

The document, consisting of 63 recommendations with comments, was reviewed by the authors (1st iteration). It was then evaluated using the Delphi method with the inclusion of a wider group of 24 experts (2nd iteration) with the following acceptance scale:

3 – Strong acceptance,
2 – Acceptance with some reservations,
1 – Acceptance with serious reservations,
0 – Rejection.

Numerous corrections and arrangements were made at the stage of document creation, thus avoiding repeated iterations at subsequent stages. It was assumed that recommendations with an average acceptance > 2 would be accepted as strong, recommendations with an average acceptance ≤ 2 and ≥ 1 as weak, and recommendations with an average acceptance < 1 would be rejected. All recommendations received an average score > 2. All expert comments were incorporated into the text. Due to the highest strength of recommendations obtained and the lack of proposals for corrections, the Delphi process was completed. The authors and invited experts participated in the process of formulating recommendations and evaluation using the Delphi method: Prof. T. Banasiewicz, Prof. A. Budzyński, Prof. A. Dziki, Prof. M. Grąt, Prof. M. Jackowski, Prof. W. Kielan, Prof. A. Matyja, Prof. M. Michalik, Prof. K. Paśnik, Prof. P. Richter, Prof. A. Szczepanik, Prof. M. Szura, Prof. W. Tarnowski, Prof. K. Zieniewicz.

Recommendations

The summary of recommendations, average rating, indication of experts raising objections and the strength of recommendation are presented in Table I. The word "Recommend" emphasizes the recommendation sentence on which the authors have reached agreement regarding the benefits for the patient from the indicated procedure, and the recommendation should be followed only if it is possible. The word "suggest" means that the patient may benefit from the indicated treatment and should be considered in making a treatment decision. The phrase "We do not recommend" emphasizes a recommen-

Table I. Laparoscopic recommendations in the ER

Recommendation	Rating	Strength of the Recommendation
1. Diagnostic laparoscopy in acute diseases		
1.1. We recommend laparoscopy in the diagnosis of acute, non-specific abdominal pain in situations where imaging studies do not allow for diagnosis and there are no contraindications to the use of this method.	2.76	Strong
1.2. Peritonitis is not a contraindication to diagnostic laparoscopy in hemodynamically stable patients.	2.88	Strong
1.3. We suggest that the first trocar be inserted openly during emergency diagnostic laparoscopy.	2.32	Strong
2. Perforated ulcer		
2.1. We suggest laparoscopic access in hemodynamically stable patients with a perforated peptic ulcer.	2.80	Strong
2.2. We do not recommend laparoscopic access if the team's skills are not sufficient to perform the operation or if appropriate and functional laparoscopic equipment is not available.	2.92	Strong
2.3. We recommend primary repair in patients with a perforated peptic ulcer less than 2 cm.	2.80	Strong
2.4. We suggest a strategy such as "damage control" in patients with septic shock due to perforated peptic ulcer and symptoms of multiple organ failure.	2.64	Strong
2.5. We do not recommend endoscopic treatment such as clipping, gluing or stenting for patients with a perforated peptic ulcer.	2.64	Strong
2.6. Based on the available data, no recommendation can be made as to whether reinforcing netting sutures may provide additional benefits.	2.40	Strong
2.7. Based on the available data, no recommendation can be made for a sutureless repair.	2.60	Strong
3. Acute pancreatitis		
3.1. We recommend an individual approach to the surgical treatment of severe AP with the participation of a multidisciplinary team.	2.92	Strong
3.2. Based on the available data, no recommendations can be made regarding the timing of surgical intervention in severe AP, regardless of the type of intervention (open, minimally invasive or endoscopic).	2.24	Strong
3.3. We suggest the use of a minimally invasive technique in a clinical situation requiring the removal of infected necrotic tissue.	2.36	Strong
3.4. In mild forms of biliary AP, we recommend laparoscopic cholecystectomy during the same hospitalization.	2.24	Strong
3.5. We recommend early ERCP and endoscopic sphincterotomy (ES) to reduce the risk of pancreatitis recurrence in biliary pancreatitis with cholangitis or bile duct obstruction and early laparoscopic cholecystectomy.	2.92	Strong
3.6. We recommend postponing cholecystectomy in acute biliary pancreatitis complicated by a peripancreatic fluid collection until resolution or stabilization of the collection and resolution of acute inflammation.	2.68	Strong
4. Incarcerated hernia		
4.1. Based on the available data, no recommendation can be made regarding the optimal technique for incarcerated hernia surgery. The surgeon choosing the method of surgical access (laparoscopic or open) should take into account the possible benefits for the patient and his own experience.	2.80	Strong

Table I. Cont.

Recommendation	Rating	Strength of the Recommendation
4.2. We recommend that you choose a surgical technique that is available at your facility to allow you to perform repair surgery as early as possible. In the case of incarcerated hernias, the most important criterion is the time in which the operation is performed, and the type of access is of secondary importance.	2.80	Strong
4.3. We suggest the use of laparoscopy to inspect the contents of the peritoneal cavity in doubtful situations, even if it is only the first stage of repair. In the repair of incarcerated hernias, the key aspect is to prevent complications related to intestinal perforation and intraperitoneal infection and to reduce mortality, while the possibility of providing simultaneous permanent reconstruction is of secondary importance.	2.68	Strong
4.4. In the laparoscopic treatment of incarcerated inguinal and abdominal hernias without contamination of the surgical field, the use of synthetic mesh does not increase the risk of septic complications.	2.71	Strong
4.5. We recommend the use of macroporous monofilament meshes during laparoscopic surgery of incarcerated inguinal hernias in clean and clean contaminated fields.	2.48	Strong
4.6. We do not recommend the use of synthetic meshes in laparoscopic surgery of hernias trapped in a contaminated and dirty field.	2.60	Strong
4.7. We recommend the use of antibiotic prophylaxis prior to laparoscopic incarcerated hernia repair, which should be continued in the postoperative period in the event of significant contamination of the operating field.	2.88	Strong
4.8. In the case of significant contamination of the operating field (intestinal perforation, purulent peritonitis), the laparoscopic method brings benefits related to the possibility of assessing the nature of the intestinal damage, its repair (resection or suture) and the simultaneous temporary closure of the primary integument defect. The definitive repair operation may be postponed and performed under planned conditions after the contamination of the operating field has subsided.	2.44	Strong
4.9. We recommend the use of a gentle technique, atraumatic instruments, moderate traction, simultaneous external pressure and a release incision on the hernial ring during laparoscopic drainage of the incarcerated hernia.	2.84	Strong
5. Acute cholecystitis		
5.1. We recommend laparoscopic cholecystectomy as the method of choice for the treatment of acute cholecystitis. This method is associated with a shorter hospitalization time and a lower risk of surgical site infection and postoperative hernias.	2.88	Strong
5.2. We recommend laparoscopic cholecystectomy for acute cholecystitis within the first 72 h of symptom onset. This creates the most technically favorable operating conditions for the operation. Performing laparoscopic cholecystectomy after this time still brings benefits to the patient, but then the operation is usually technically more difficult, takes longer, and it is more often necessary to convert to the open method.	2.88	Strong
5.3. We recommend antibiotic prophylaxis prior to laparoscopic cholecystectomy for acute cholecystitis.	2.92	Strong
5.4. In the presence of choledocholithiasis, the decision on a two-stage treatment strategy (ERCP plus laparoscopic cholecystectomy) or a single-stage treatment strategy (laparoscopic cholecystectomy with biliary revision) should depend on the experience of the surgical team and the availability of an endoscopic laboratory.	2.92	Strong
5.5. We recommend dissection of the area of the alveolar triangle taking into account the Critical View of Safety (CVS) criteria to reduce the risk of iatrogenic biliary injury during laparoscopic cholecystectomy for acute cholecystitis.	3.00	Strong

Table I. Cont.

Recommendation	Rating	Strength of the Recommendation
5.6. We do not recommend reducing the number of trocars during laparoscopic cholecystectomy for acute cholecystitis.	2.80	Strong
5.7. We recommend conversion to an open approach or subtotal cholecystectomy if the CVS criteria cannot be met or intraoperative biliary imaging is unavailable.	2.80	Strong
5.8. There is no clinical evidence for the benefit of routine drainage after cholecystectomy in acute cholecystitis.	2.08	Strong
5.9. If iatrogenic damage to the bile ducts is found during laparoscopic cholecystectomy, we recommend drainage around the follicle bed (avoiding drainage of individual ducts). The patient with a detailed description of the operation (or video documentation) should be immediately transferred to a center experienced in biliary tract repair operations.	2.92	Strong

dation statement on which the authors fully agreed on the increased risk or lack of additional benefit to the patient with the indicated procedure.

Absolute and relative contraindications to laparoscopy

On the matter of dissemination of minimally invasive methods, absolute contraindications for laparoscopic surgery have been limited to only a few clinical situations.

We do not recommend laparoscopic surgery in the following cases of absolute contraindications, which include:

- hemorrhagic or septic shock with concomitant hemodynamic instability,
- deep disorders of the coagulation system without the possibility of safe and reliable hemostasis,
- severe circulatory and respiratory failure,
- lack of full efficiency of devices and tools for laparoscopy [15].

The use of laparoscopy should not be forced in cases where it would be associated with a significantly prolonged procedure or the need to postpone it. An obvious element that cannot be omitted is the need to obtain the patient's consent for laparoscopic surgery. An important, and perhaps the most difficult to recognize, limitation and contraindication are the laparoscopic skills of the operating surgeon. Insufficient training and limited experience of the surgical team significantly increase the risk of serious complications. At the same time, insufficient equipment or inadequate training of the support staff should be treated as a relative contraindication to advanced laparoscopic procedures [16].

Factors limiting the use of minimally invasive access can be both anatomical, physiological and related to the disease. Unfavorable anatomical relations, massive adhesions, enlargement of abdominal organs, or distension of intestinal loops may hinder safe access to the peritoneal cavity or exposure of the surgical field.

Relative contraindications to perform laparoscopy are:

- third trimester of pregnancy,
- increased intracranial pressure,
- low heart ejection fraction,
- large abdominal aortic aneurysm with the risk of rupture with insufflation of the peritoneal cavity,
- impaired gas exchange in the lungs,
- diffuse peritonitis,
- chronic liver diseases (liver cirrhosis and portal hypertension),
- coagulopathies,
- lack of proper training of the surgeon [15, 17].

An element of the safety of laparoscopic operations is the ability to make a decision about conversion to open surgery. Conversion is associated with the loss of benefits associated with surgery in the laparoscopic technique, so the decision should not be taken hastily. However, this decision should not be delayed in certain situations, as it can save the patient's health and life. The conversion is not a failure of the surgeon, but a proof of his extensive experience and high level of knowledge.

Indications for conversion include:

- bleeding that cannot be controlled laparoscopically in a short time,
- unstable pneumothorax and other causes of loss of stable field exposure,

– loss of orientation in the operating field or lack of clear anatomy,
– instability of the patient's condition related to pneumothorax or body position,
– equipment malfunction, loss or lack of a necessary tools,
– other factors preventing the continuation of laparoscopic surgery.

Enhanced Recovery After Surgery (ERAS) program

Due to the high variability of the clinical condition of patients operated on in the emergency department, the authors did not formulate clear guidelines for optimizing perioperative care (usually called ERAS) after emergency surgery. Nevertheless, the authors both use such a procedure in their practice, and there is a lot of evidence for the effectiveness of this concept. A significant percentage of patients benefit from accelerated rehabilitation implemented postoperatively, despite the lack of prehabilitation and elements of preoperative management [18, 19]. As in elective procedures, more burdened patients, including geriatric patients, benefit more from ERAS [20].

1. Diagnostic laparoscopy in acute diseases

1.1. We recommend laparoscopy in the diagnosis of acute, non-specific abdominal pain in situations where imaging studies do not allow for diagnosis and there are no contraindications to the use of this method.

Acute, non-specific abdominal pain is defined as abdominal or pelvic pain lasting less than 7 days, the cause of which cannot be identified by a complete clinical examination and additional investigations. The use of diagnostic laparoscopy allows one to accelerate the initiation of causal treatment, but also to avoid unnecessary laparotomy during the emergency call, which is associated with increased incidence of postoperative complications, reaching up to 22% of patients [21, 22]. The value of diagnostic laparoscopy is particularly visible in women of childbearing age and allows the frequency of unnecessary laparotomies and appendectomies to be reduced [23, 24].

When diagnostic laparoscopy is used, the effectiveness of diagnosing the cause of acute, non-specific abdominal pain is as high as 85–98% [25, 26]. In addition, after intraoperative diagnosis, most patients can continue laparoscopic treatment. In economically highly developed countries, the percentage of procedures performed using minimally invasive access in emergencies reaches 69.6% [26–28].

Although acute appendicitis is a fairly common pathology, clinical symptoms may be non-specific and make differential diagnosis difficult [29]. This is especially true for young women, whose reproductive system symptoms may resemble the clinical picture of appendicitis. At the same time, delay in diagnosis and treatment may lead to typical complications of perforation and/or diffuse peritonitis [30]. It was found that in 15% of all appendectomies, appendicitis was not confirmed [31]. Even the use of modern imaging diagnostics does not show sufficient sensitivity and specificity to confirm or rule out appendicitis. Ultrasound sensitivity is estimated at 71–94% and specificity at 81–98% [32]. Computed tomography has a sensitivity of 76–100% and a specificity of 83–100% [33]. Magnetic resonance imaging reaches a sensitivity of about 92–99% and a specificity of 94–99% [34].

Among the numerous advantages of laparoscopic appendectomy, the latest guidelines emphasize the diagnostic value of minimally invasive access, which is of particular importance in young women and allows for a definitive differential diagnosis [35, 36]. Gaitán *et al.* published a Cochrane literature review showing that laparoscopic access in women with non-specific pain in the right lower abdomen significantly increased the rate of specific diagnoses compared to the open method (OR = 4.10; 95% CI: 2.50–6.71) and the "wait and see" strategy (OR = 6.07; 95% CI: 1.85–29.88) [37]. In addition, in the case of laparoscopy, the decision to remove the unchanged appendix was made less frequently compared to the open method. Widespread use of diagnostic laparoscopy shortens the total time of hospitalization and reduces the costs of treatment of patients admitted during emergency duty [24, 27, 38, 39].

1.2. Peritonitis is not a contraindication to diagnostic laparoscopy in hemodynamically stable patients.

The use of laparoscopic access is inextricably linked to the need to create a pneumoperitoneum. In addition to creating the operating space, it has an impact on changes in the circulatory and respirato-

ry systems [40, 41]. An increase in intra-abdominal pressure, by compressing the inferior vena cava, may reduce venous return, and thus reduce the stroke volume of the heart and affect organ perfusion. In addition, the forced, high setting of the diaphragm reduces tidal volume and increases the risk of atelectasis at the base of the lungs.

Doubts regarding the use of laparoscopy in patients with diffuse peritonitis are mostly based on fears of a hypothetical increase in bacteremia and toxemia after a pneumoperitoneum [42]. However, this theory was not reflected in evidence-based medicine (EBM). The benefits of reduced surgical trauma significantly outweigh the risks associated with increased intraperitoneal pressure. Numerous studies comparing the use of laparoscopic surgery and open surgery in patients with peritonitis indicate a lower risk of septic complications in the postoperative period in the group of patients operated on laparoscopically [22, 26, 27, 43–47]. Peng *et al.* also reported that the inflammatory response of the body, measured in the postoperative period by the concentration of leukocytes, C-reactive protein, tumor necrosis factor-α (TNF-α), and interleukin 2 and 6, is significantly lower after laparoscopic surgery in patients with peritonitis [43].

1.3. We suggest that the first trocar be inserted openly during emergency diagnostic laparoscopy.

Commonly used methods for inserting the first trocar during laparoscopy are the open method (Hasson technique) and the Veress needle method. Both methods have a low risk of complications (< 1%) during insertion of the first trocar [42]. However, it is emphasized that special care must be taken when inserting the first trocar in selected patients, especially after operations, in the case of enlargement of parenchymal organs and obstruction of the gastrointestinal tract. So far, no significantly greater safety has been proven for any of the mentioned methods [48–52]. It is worth noting, however, that studies comparing the two methods included groups of patients undergoing elective surgery. Although there is no evidence in the available literature on a higher risk of complications from the use of the Veress needle during diagnostic laparoscopy in emergency patients, considering the lack of diagnosis and the presence of acute intra-abdominal disease, particular caution may induce the use of a method that allows additional visual control during first trocar insertion – minilaparotomy.

Comment

In many clinical situations (e.g., acute cholecystitis or appendicitis) in patients with normal anatomy, no previous surgery, and no abdominal distension, it is safe to use the Veress needle (JSo).

2. Perforated ulcer

2.1. We suggest laparoscopic access in hemodynamically stable patients with a perforated peptic ulcer.

2018 Cirocchi's meta-analysis comparing laparoscopic perforation repair vs. open surgery including 8 RCTs with a total of 615 patients (307 laparoscopic and 308 open surgery). The comparison showed a significant advantage of laparoscopy in terms of postoperative pain control (–2.08; 95% CI: –2.79 to –1.37) and a lower risk of postoperative wound infection (RR = 0.39; 95% CI: 0.23–0.66). There were no significant differences between laparoscopic and open surgery in terms of overall postoperative mortality, leaks, intra-abdominal infections, and reintervention rates [53]. This undoubtedly constitutes an advantage of laparoscopy; however, it must require appropriate technical skills and equipment from the surgeon. Moreover, the studies included in the analysis turned out to be burdened with a high risk of error.

Considering the impact of CO_2 pneumoperitoneum on the circulatory and respiratory systems, it is not recommended to use laparoscopic perforation repair in patients with significant hemodynamic or respiratory burdens, as it may cause significant, further deterioration of their function [53–55].

2.2. We do not recommend laparoscopic access if the team's skills are not sufficient to perform the operation or if appropriate and functional laparoscopic equipment is not available.

Laparoscopic surgery requires a high degree of focus, dexterity, and technical skill. Most surgeons require initial training to become proficient in these complex procedures through repeated repetition of specific exercises. Acquiring proficiency in emergency laparoscopy requires a longer period of training than electives. The initial training period varies by surgeon and procedure [56]. When lap-

aroscopic procedures are performed by untrained surgeons without proper supervision, it increases operative time and results in higher risk of conversion, mortality, morbidity, length of stay and readmissions [57].

2.3. We recommend primary repair in patients with a perforated peptic ulcer less than 2 cm.

Risk factors for conversion include perforations greater than 1 cm with symptoms lasting more than 12 h. In the case of perforations exceeding 2 cm, the risk of resection operations also increases, especially in the case of a suspected oncological cause of perforation [55, 58–60].

In patients with perforated peptic ulcers, we suggest short-term antibiotic therapy (3–5 days or until inflammatory markers return to normal). Broad-spectrum antibiotic therapy should be started as soon as possible, optimally after the material from the peritoneum has been collected for bacteriological examination. Modification of antibiotic therapy is possible after obtaining culture results. Research shows that in the case of successful surgical treatment, prolongation of antibiotic therapy does not bring additional benefits [61, 62].

2.4. We suggest a strategy such as "damage control" in patients with septic shock due to perforated peptic ulcer and symptoms of multiple organ failure.

Peritonitis due to ulcer perforation may progress rapidly to septic complications, including septic shock with rapidly progressive organ failure. In severe cases of perforation with symptoms of septic shock, laparoscopy is not the approach of choice and staged management should be considered, the first element of which is "damage control" while leaving the "belly open" [55, 63, 64].

2.5. We do not recommend endoscopic treatment such as clipping, gluing or stenting for patients with a perforated peptic ulcer.

The literature describes the use of endoscopic techniques in the case of iatrogenic gastrointestinal perforations. However, in patients with perforated gastric or duodenal ulcers, the results of treatment using endoscopy are unsatisfactory, and so far these techniques cannot be recommended as routine management [65, 66].

2.6. Based on the available data, no recommendation can be made as to whether reinforcing netting sutures may provide additional benefits.

Numerous studies have not shown significant benefits of strengthening the suturing site with a net flap, while extending the duration of the surgical procedure. Also, with perforations larger than 2 cm, strengthening the suturing site with a net flap does not improve the treatment results [67–70].

2.7. Based on the available data, no recommendation can be made for a sutureless repair.

Studies comparing the use of tissue adhesives compared to perforation suturing clearly indicate a higher risk of leakage (16% vs. 6%) and a higher rate of conversion (10% vs. 4%) in patients with sutureless techniques [71, 72].

3. Acute pancreatitis

Although operations in the course of acute pancreatitis (AP) are usually not performed on a regular basis, but in an urgent manner and should be carefully planned and performed during the day, with full daily protection, AP is classified as an acute abdominal disease and therefore the pathology has been included in the guidelines. At the same time, we would like to point out that endoscopy plays an increasingly important role in the drainage of abscesses and removal of pancreatic necrosis, but its discussion goes beyond the scope of this paper.

3.1. We recommend an individual approach to the surgical treatment of severe AP with the participation of a multidisciplinary team.

In infected pancreatic necrosis, staged type treatment is recommended step up, which postpones definitive surgical treatment until more favorable conditions for surgery appear or it is possible to avoid such an intervention. Curing the infection in the early stages of therapy is possible in as many as 25–60% of patients. A systematic review analyzing percutaneous drainage of the peripancreatic space, including 11 available studies, showed a satisfactory therapeutic effect of drainage in 56% of patients, which allowed the planned surgical intervention to be abandoned or

postponed until the risk of surgery-related morbidity was reduced (demarcation period) [73].

3.2. Based on the available data, no recommendations can be made regarding the timing of surgical intervention in severe AP, regardless of the type of intervention (open, minimally invasive or endoscopic).

To determine the nature of AP complications, the modified Atlanta classification from 2012 (ANC – acute necrotic collection, APFC – acute peripancreatic fluid collection, WOPN – walled-off pancreatic necrosis) should be used.

Unless necrotic infection has occurred, most forms of morphological complications of AP do not require special surgical management. The most commonly used surgical interventions in APFC or WOPN are minimally invasive procedures, mainly percutaneous drainage, laparoscopic or endoscopic drainage [74]. It should be emphasized that percutaneous drainage has a lower success rate compared to other invasive methods, which may mean the need for additional interventions or complications in the form of e.g. external fistulas [75].

A systematic review of six trials found no differences in success rates, complications, and recurrence between surgical and endoscopic approaches, although the latter had shorter hospital stays and lower treatment costs [76]. Open cystogastrostomy is no longer the first-line treatment for pseudocysts. In the observational study, the endoscopic procedure is characterized by better comfort during the recovery period, a lower rate of complications (10% vs. 60%) and a shorter hospital stay (6.2 days vs. 11.0 days) [77]. However, there are no differences between laparoscopy and endoscopic drainage in terms of effectiveness, recurrence and complication rate [78]. The latest meta-analyses, in a direct comparison of percutaneous, laparoscopic and endoscopic drainages, suggest preferring endoscopic methods as they give comparable effects and a similar percentage of complications, with a significant reduction in hospitalization time [79, 80].

The moment of minimally invasive intervention in the "step-up" strategy in acute necrotizing pancreatitis remains controversial. There are data suggesting the maximum delay of intervention until the demarcation of necrotic foci (over 4 weeks) after the use of antibiotic therapy, as well as showing the benefits of intervention applied immediately after the diagnosis of necrotic infection [81].

3.3. We suggest the use of a minimally invasive technique in a clinical situation requiring the removal of infected necrotic tissue.

The use of MIS in the treatment of infected necrosis became the standard after the publication of the results of the RCT PANTER, which showed the advantage of minimally invasive interventions over open surgery in terms of early and long-term outcomes [82]. Currently, the most highly rated procedures for drainage of abscesses and removal of infected necrosis of the pancreatic parenchyma or peripancreatic tissues are percutaneous drainage and laparoscopic necrosectomy (VARD – video-assisted retroperitoneal debridement, LTN – laparoscopic transgastric debridement) or endoscopic drainage.

The primary MIS treatment is VARD, which has been proven effective in the RCT PANTER [83]. The laparoscopic technique is used here after prior application of percutaneous or endoscopic drainage. Treatment regimen should be individualized in each case, which can basically be a combination of different approaches and techniques. However, there are several reports showing the advantage of endoscopic management in the step-up strategy, in which the role of the laparoscopic technique is taken over by endoscopy. Endoscopic drainage is characterized by a lower rate of complications, fistulas, lower treatment costs, and greater patient comfort (PENGUIN and MISER studies) [84].

Minimally invasive surgical treatment, such as endoscopic transgastric necrosectomy or VARD, results in less inflammatory response to trauma and postoperative multiple organ failure compared to open methods. However, it may require more interventions [85]. In selected cases of WOPN and in patients with a damaged pancreatic duct, single-stage transgastric surgical necrosectomy may be effective [86, 87].

3.4. In mild forms of biliary AP, we recommend laparoscopic cholecystectomy during the same hospitalization.

There are reports showing the safety of laparoscopic cholecystectomy performed immediately after the symptoms of mild biliary AP have subsided during the primary hospitalization [88, 89]. A Cochrane meta-analysis found shorter cholecystectomy time and a significantly lower risk of recurrence of biliary complications [90]. However, in the randomized controlled trial (RCT) published in 2020, it was found that such

a procedure significantly reduces the average hospitalization time and does not increase the percentage of adverse events [91]. After previous endoscopic retrograde cholangiopancreatography (ERCP), the risk of recurrent biliary incident remains higher than the risk of cholecystectomy alone, performed during the same stay. Deferred cholecystectomy may be associated with a higher risk of AP recurrence and biliary incidents, with a comparable risk of the gallbladder removal procedure itself (e.g. RCT PONCHO) [92–94]. On the other hand, performing cholecystectomy during hospitalization during which more advanced than mild forms of AP were diagnosed may be associated with an increased risk of perioperative complications, including mortality [95–97].

3.5. We recommend early ERCP and endoscopic sphincterotomy (ES) to reduce the risk of pancreatitis recurrence in biliary pancreatitis with cholangitis or bile duct obstruction and early laparoscopic cholecystectomy.

Early performance of ERCP and ES reduces the risk of urolithiasis-related AP complications [98]. This effect was demonstrated in both patients with and without cholangitis [99]. Another multicenter randomized study published in 2020 found that urgent ERCP with ES in biliary acute pancreatitis without cholangitis, when severe cholangitis is likely, does not reduce the rate of severe disease complications compared to conservative management [100].

3.6. We recommend postponing cholecystectomy in acute biliary pancreatitis complicated by a peripancreatic fluid collection until resolution or stabilization of the collection and resolution of acute inflammation.

Schepers *et al.* demonstrated the validity of postponing cholecystectomy in patients with acute biliary pancreatitis with a concomitant peripancreatic fluid collection. The right time for surgery is the moment of resolution of acute inflammation and complete resorption or stabilization of the size of the fluid reservoir [101].

4. Incarcerated hernias

4.1. Based on the available data, no recommendation can be made regarding the optimal technique for incarcerated hernia surgery. The surgeon choosing the method of surgical access (laparoscopic or open) should take into account the possible benefits for the patient and his own experience.

There are no high-quality studies in the literature comparing different surgical approaches for incarcerated inguinal hernias, and the available analyses are based on a small number of cases. Karatepe *et al.* found that in the case of incarcerated inguinal hernia, preperitoneal repair surgery is associated with similar results to Lichtenstein open access surgery [102]. Leibl *et al.* presented the results of a prospective analysis of 220 incarcerated inguinal hernia repair procedures, of which 194 were performed using the transabdominal preperitoneal (TAPP) technique [103]. The authors found no differences in the duration of the operation between classic open and laparoscopic access. Recurrence and synthetic mesh infection rates after TAPP procedures were low (0.5% and 0.1%, respectively) and similar to open access procedures. However, the authors pointed out that a significant benefit of TAPP surgery is the possibility of simultaneous assessment of the bowel condition.

Saggar *et al.* retrospectively assessed a group of 286 patients with inguinal hernia operated on by the totally extraperitoneal (TEP) method, of whom 34 patients underwent surgery due to hernia incarceration. In the group of patients operated on urgently, they found a significantly higher risk of recurrence (5.8% vs. 0.35%) and more frequent occurrence of scrotal hematomas in the postoperative period. Saggar drew attention to the possible necessity of conversion to intraperitoneal access in order to assess the condition of the trapped intestine (17.6%) [104]. Considering these aspects, the greater benefit of incarcerated hernia surgery with TAPP than with TEP is emphasized [105, 106].

At the same time, there is a widespread belief in the literature about the benefits of using the laparoscopic technique over the open method, precisely because of the possibility of simultaneous assessment of the condition of the intestine [107–109].

An additional advantage of the laparoscopic technique is the possibility of simultaneous repair of the entire musculo-pectineal hiatus. This is of particular importance in women who may have coexisting femoral and inguinal hernias, and women with femoral hernias are particularly at risk of incarceration [110, 111].

However, many authors point out that the surgeon undertaking incarceration repair must have considerable experience in routine elective laparoscopic hernia repair [103, 112, 113]. Currently, it is emphasized that approximately 65–100 TAPP oper-

ations are required to overcome the learning curve of this technique [114, 115]. At the same time, only after performing about 200 procedures do surgeons usually reach for advanced and difficult cases, including incarcerated and repeatedly recurrent hernias [116].

4.2. We recommend that you choose a surgical technique that is available at your facility to allow you to perform repair surgery as early as possible. In the case of incarcerated hernias, the most important criterion is the time in which the operation is performed, and the type of access is of secondary importance.

In a retrospective cohort study based on data from the Swedish hernia registry (Swedish Hernia Register) of 103,710 patients operated on for inguinal hernia, Nilsson *et al.* reported 292 deaths within 30 days of surgery, the vast majority of which occurred after incarcerated hernia repair (64% vs. 36%) [117]. In the case of deaths after hernia operations in women, this trend was even more pronounced and as many as 91% of deaths occurred after emergency surgery. Similar data were published by Bay-Nielsen *et al*. based on the Danish hernia registry (Danish Hernia Database). Among 1829 patients operated on urgently due to incarceration of inguinal hernia, death occurred within 30 days after surgery in as many as 147 (8%) cases. Patients in whom repair surgery was performed within the first 8 h from admission to the hospital accounted for only 23.4% of all cases that ended in death [118]. The authors of both studies emphasized that in the case of incarcerated hernia, it is crucial to shorten the time to start surgery as much as possible [117]. For this purpose, it is necessary to limit preoperative diagnostic imaging tests to a minimum and to use the available surgical technique. The operation should be performed as soon as possible, taking into account the currently available tools, current staff and team experience [119]. If the facility's capabilities allow laparoscopic surgery, and the current team has appropriate experience in laparoscopic technique, laparoscopic surgery is recommended, optimally TAPP. Prolonging the time to start surgery is associated with a higher risk of bowel resection, longer operative time, longer hospital stay, more complications and higher mortality, regardless of the surgical method used [120]. Karatepe *et al.* reported that if surgery was performed within 24 h of the onset of incarceration symptoms, bowel resection was significantly less likely (29% vs. 49%, $p = 0.047$) [102]. Therefore, if creating the possibility of laparoscopic surgery is associated with long-term waiting for the team to be completed, tools to be prepared or the patient to be transported to another center, the open access method should be used.

4.3. We suggest the use of laparoscopy to inspect the contents of the peritoneal cavity in doubtful situations, even if it is only the first stage of repair. In the repair of incarcerated hernias, the key aspect is to prevent complications related to intestinal perforation and intraperitoneal infection and to reduce mortality, while the possibility of providing simultaneous permanent reconstruction is of secondary importance.

Sgourakis *et al.* in a randomized study found that laparoscopy through the hernial sac after removal of the incarcerated contents can be an accurate and safe method of assessing the condition of the intestine, preventing unnecessary laparotomies [121]. The authors emphasized that this is of particular importance in the group of patients with high perioperative risk, as it allows the number of complications and morbidity to be reduced.

In another retrospective study, Tebala *et al.* presented the results of hernioplasty after removal of the incarcerated hernia contents to assess the condition of the intestine, which avoided simultaneous laparotomy in all cases [122]. Half of the operated patients showed no signs of permanent organ damage or peritonitis, so it was possible to perform a definitive repair operation at the same time using a synthetic material.

When the laparoscope optics are introduced not through the hernial sac, but in a typical way through the trocar in the umbilical region, there is a possibility of an even wider view into the peritoneal cavity, possible peritoneal lavage and suction of the contents, as well as identification of the damaged segment of the intestine with repair of the perforation site or segmental resection of the intestine [123]. If the peritoneal contamination, in the opinion of the surgeon, raises concerns about the use of a synthetic implant at the same time, then it is possible to perform only basic repair using the patient's tissues from the open access or only temporary suturing of the peritoneum of the hernia gate with postponed final repair [124]. In such situations, it is possible to avoid laparotomy, reduce the contamination of the

operating field and treat a life-threatening perforated or necrotized segment of the intestine.

4.4. In the laparoscopic treatment of incarcerated inguinal and abdominal hernias without contamination of the surgical field, the use of synthetic mesh does not increase the risk of septic complications.

As in elective surgery, the use of synthetic meshes is recommended for incarcerated inguinal hernias in a clean field [125]. The use of synthetic material in these cases does not increase the number of surgical site infections compared to tension methods [126]. In addition, in cases without peritonitis and no need for bowel resection, the use of mesh is safe, associated with a low number of complications and a low recurrence rate [127].

The use of the laparoscopic technique using a synthetic mesh in the clean field is associated with a lower frequency of infections compared to the Lichtenstein method (OR = 0.39; 95% CI) [128, 129]. Sakamoto *et al*., based on data collected in the register of hospitalizations in Japan, analyzed the treatment results of 668 patients operated on due to incarcerated inguinal hernia during a 5-year follow-up [130]. Every third operation was performed using a synthetic implant. There was no difference in the rate of surgical site infection between the mesh and non-mesh groups (2.5% vs. 2.8%, $p = 0.79$).

4.5. We recommend the use of macroporous monofilament meshes during laparoscopic surgery of incarcerated inguinal hernias in clean and clean contaminated fields.

In a prospective cohort study, Atila *et al.* investigated the use of synthetic mesh in a clean-contaminated field in incarcerated inguinal hernia surgery [127]. They compared the results of treatment with the implantation of a synthetic material in cases of intestinal resection and operations without the need to remove a fragment of the intestine. The authors found no difference in the number of perioperative complications, surgical site infections, hematomas, seromas and recurrences. In no case did the mesh become infected or need to be removed. However, Atila emphasizes that monofilament mesh was used in all cases.

If the condition of the trapped intestine raises doubts and indicates its irreversible damage, segmental resection of the intestine should be performed [103, 113, 131]. First, however, the repair stage of the hernia operation should be completed with the placement of a synthetic implant in the preperitoneal space and closure of the peritoneal defect. Bowel resection can then be performed both laparoscopically and openly. Sawayama *et al.* showed that the use of a mesh simultaneously with bowel resection in a clean-contaminated field is possible, as long as the surgeon maintains the described sequence of operation stages with limited contamination of the space in which the mesh is placed [132]. An additional advantage of such a procedure is the possibility of assessing the viability of the intestine after the period of time intended for treating the hernia in the first place. Liu *et al.* reported that almost 10% of 97 patients operated on due to intestinal entrapment had a high suspicion of irreversible intestinal damage [109]. However, these patients avoided resection because the bowel condition improved during TAPP hernia repair.

The use of macroporous meshes, with a pore diameter of at least 1 mm, allows for the free movement of body fluids and the migration of immune system cells [133]. These materials help to reduce the sequestration of fluids, which, if contaminated, could lead to the formation of an abscess or fistula. Therefore, in the case of operations in a clean contaminated field, it is recommended to use macroporous meshes [134]. Particular attention should be paid to the distribution and possible fixing of the synthetic material in such a way as to prevent the mesh from bending, wrinkling and folding, which limits the preservation of the macroporous structure of the mesh [135].

4.6. We do not recommend the use of synthetic meshes in laparoscopic surgery of hernias trapped in a contaminated and dirty field.

There are no data in the literature evaluating the possibility of using a synthetic mesh in a contaminated and dirty field. However, the authors of many works emphasize that in these cases they did not use a grid, and the final repair was postponed. Sakamoto *et al*., in an analysis of 934 patients operated on due to incarcerated inguinal hernia, identified a group of 88 (9.4%) patients with diffuse peritonitis, in whom synthetic mesh implantation was abandoned, thanks to which an increased frequency of surgical site infections was not demonstrated in the

remaining patients [130]. Topcu *et al.* retrospectively analyzed the results of 154 patients operated on due to incarcerated hernia [136]. In 36 patients, the necrotizing omentum was resected, in 23 patients resection of the damaged small intestine was performed, and in 2 patients the colon was resected. Among the patients who underwent resection, in 9.4% surgical site infections were found, while in the group without resection there were no infections.

Current recommendations of the European Hernia Society, HerniaSurge Group, and International Endohernia Society do not recommend the use of synthetic materials in the presence of infection in the operating field [107, 108, 114, 137]. In these situations, it is possible to repair the patient's own tissues or to use biological materials, but both of these methods are associated with a higher risk of hernia recurrence [138].

4.7. We recommend the use of antibiotic prophylaxis prior to laparoscopic incarcerated hernia repair, which should be continued in the postoperative period in the event of significant contamination of the operating field.

In elective surgery, the routine use of antibiotic prophylaxis is not recommended for patients at moderate or low risk of infection unless the patient is operated on in a center with a low infection rate [114]. However, in the case of urgently operated hernias, it should be assumed that incarceration is in itself a high risk factor; therefore antibiotic prophylaxis is administered immediately before the procedure is indicated. The surgeon is able to assess the degree of contamination of the operating field only during the operation. In the analysis of 14,053 inguinal hernia operations with the Swedish Hernia Registry, it was estimated that only 5.6% of patients were classified as being at high risk of infection and received antibiotic prophylaxis, which allowed for a low infection rate in this group (1.2% in men and 1.5% in women) [117]. In addition, the inflammatory infiltration and tissue fragility accompanying the edema of the affected structures promote organ damage during the laparoscopic manipulations. Therefore, in these patients, antibiotics should be administered earlier. If signs of organ necrosis are found intraoperatively (greater omentum, small intestine, appendix, colon) and/or diffuse peritonitis, additional antibiotic therapy should be introduced in the postoperative period for a minimum of 3 to 5 days [139].

4.8. In the case of significant contamination of the operating field (intestinal perforation, purulent peritonitis), the laparoscopic method brings benefits related to the possibility of assessing the nature of the intestinal damage, its repair (resection or suture) and simultaneous temporary closure of the primary integument defect. The definitive repair operation may be postponed and performed under planned conditions after the contamination of the operating field has subsided.

The risk of infection of the synthetic mesh in the case of diffuse purulent or fecal peritonitis is very high and is associated with a higher incidence of relapses, enterocutaneous fistulas and abscesses. For this reason, in cases of significant contamination of the peritoneal cavity, it is recommended to perform only a repair operation using the patient's own tissues [140]. This can be done laparoscopically with only temporary suturing of the peritoneum at the level of the hernia gate and postponing the date of definitive surgery until the inflammation and infection subside [103]. Alternatively, it is possible to perform a voltage repair operation from the anterior approach (optimally, the Shouldice method) [113]. Simultaneous laparoscopic surgery in these cases makes it possible to identify the source of infection (intestinal perforation, incarcerated appendicitis, etc.) and to take the necessary steps to remove the source of contamination [107, 108].

In addition, laparoscopy allows for the toilet of the peritoneal cavity without the need for laparotomy. Chihara *et al*., based on the analysis of seven years of observation of their own experience, found that only 2% of all laparoscopic procedures of incarcerated inguinal hernias required conversion to laparotomy [141]. At the same time, the study indicated that 15.2% of patients received a two-stage treatment consisting in draining the hernia content with segmental resection of the intestine and only primary laparoscopic suturing of only the peritoneum with drainage of the retroperitoneal space. After only a few weeks, the final repair was performed using the TAPP method with the placement of a synthetic implant. There was no mesh infection in any of the patients.

4.9. We recommend the use of a gentle technique, atraumatic instruments, moderate traction, simultaneous external pressure and a release incision on the hernial ring during laparoscopic drainage of the incarcerated hernia.

The key step in incarcerated hernia surgery is drainage of the contents of the hernial sac [142]. The hernial ring may need to be widened [113]. To avoid damage to the external iliac or inferior epigastric vessels, the incision should be made in the appropriate direction depending on the location of the hernia. In the case of simple inguinal (medial) hernias, the annulus incision should be made in the medial superior (medial-cranial) direction. In oblique (lateral) inguinal hernias, the annulus is incised laterally. In femoral hernias, the lacunar ligament (Gimbernat) located on the medial side of the femoral canal, between the inguinal ligament (iliopubic band) and Cooper's ligament, should be cut. An incision of the annulus in the preperitoneal space, outside of the peritoneum of the hernial sac, makes it possible to reduce the risk of damaging the incarcerated hernia content [142, 143]. Mancini *et al.* found that ring incision was necessary in 40% of all incarcerated inguinal hernia repair procedures [144].

To reduce the risk of bowel injury or rupture of the trapped contents, simultaneously apply external pressure to the hernia and attempt to slowly pull the contents inward along the line of least resistance, maintaining moderate traction at all times. Atraumatic laparoscopic instruments should be used (large surface of the gripping part of the laparoscopic instrument, finely serrated, fenestrated gripping surface). Both forceful pulling of the intestine and manipulation of the intestine without visual control are unacceptable, as this increases the risk of intestinal perforation and bleeding [145].

5. Acute cholecystitis

5.1. We recommend laparoscopic cholecystectomy as the method of choice for the treatment of acute cholecystitis. This method is associated with a shorter hospitalization time and a lower risk of surgical site infection and postoperative hernias.

Acute cholecystitis is one of the most common reasons for urgent surgical interventions [146, 147]. Early laparoscopic cholecystectomy is currently the recommended treatment [148]. According to the current criteria of the *Tokyo Guidelines*, only in selected narrow groups of patients, in whom surgical intervention is associated with a very high perioperative risk, should other therapeutic procedures be considered [149].

Laparoscopic cholecystectomy is associated with a number of advantages over open cholecystectomy. It allows one to reduce the number of infections of the operated site, affects the patient's faster convalescence, and shortens the time of hospitalization and return to full activity [150, 151]. In the longer term period after surgery, it improves the quality of life and helps to reduce the occurrence of abdominal hernias [152]. In a systematic review of meta-analyses, Coccolini *et al.* concluded that the laparoscopic approach, compared to the open approach, allows one to halve the overall number of complications (OR = 0.46; 95% CI: 0.21–0.72), including surgical site infections (OR = 0.54) and pneumonia (OR = 0.51) [147]. Laparoscopic cholecystectomy allowed for a five-fold reduction in mortality in patients with acute cholecystitis compared to open cholecystectomy. Hospitalization time was on average 4.74 days shorter after minimally invasive surgery.

There was no difference in the duration of surgery. However, it should be emphasized that despite the benefits of laparoscopic access, in cases of doubt as to the identification of the prepared structures, conversion to the open method should be considered [153].

Elderly patients with acute cholecystitis pose a therapeutic challenge in acute surgery. On the one hand, certain benefits associated with limiting surgical interventions to the necessary minimum are pointed out, e.g. for percutaneous drainage in particularly burdened patients [154]. On the other hand, it is emphasized that advanced age, apart from diabetes, high CRP values, the presence of gallbladder necrosis or abscess, is associated with more frequent conversions (up to 22.5%) to open cholecystectomy, which puts more strain on the patient [155]. For this reason, the optimal solution in this group of patients is to perform laparoscopic cholecystectomy as soon as possible from the onset of symptoms, although taking into account the simultaneous treatment of accompanying diseases [156].

Zhang *et al.*, based on an analysis of 412 elderly patients, divided into two groups above and below 80 years of age, found that in the group of the oldest patients, heart failure, hypertension, chronic obstructive pulmonary disease (COPD) and anemia were much more common, and laparoscopic cholecystectomy lasted longer, there was more blood loss, more pneumonia and electrolyte disturbances [156]. Despite this, these patients continued to benefit from laparoscopic surgery, but the prerequisite

was the simultaneous treatment of comorbidities, not postponing the date of surgery. Similar conclusions were presented by Loozen *et al*., who, based on an analysis of 703 patients with acute cholecystitis, stated that despite the presence of ASA ≥ 3 in the group of patients over 75 years of age (37% vs. 8%, $p < 0.001$), higher incidence of complications (17% vs. 8%, $p < 0.004$), with higher risk of conversion (18% vs. 5%, $p < 0.001$) and longer hospital stay after surgery (5 vs. 3 days, $p < 0.001$), it was still the oldest patients who benefited from early laparoscopic cholecystectomy compared to conservative treatment, delayed cholecystectomy after percutaneous drainage or open cholecystectomy [154, 157].

Obesity is a risk factor for gallstones; it can lead to acute cholecystitis, which in turn requires a cholecystectomy. However, surgeons do not fully agree on optimal surgical access, especially in morbidly obese patients. The main concerns are potential technical difficulties and the lack of sufficient exposure of the operating field in laparoscopy. Rudasill *et al.* presented the results of a retrospective analysis of 327,473 patients who underwent gallbladder removal and divided them into 5 groups according to body mass index (BMI) [158]. The authors reported that in the group of patients with morbid obesity (BMI ≥ 40 kg/m^2), even lower mortality was found compared to the group of people with normal BMI, and the highest mortality was in the group of malnourished patients (BMI < 18.5 kg/m^2). On the other hand, in the group of patients with morbid obesity, the operation time was longer (10.2 min on average, $p < 0.001$), wound infections more frequent (OR = 1.38, $p < 0.001$) and wound dehiscence more frequent (OR = 2.2, $p < 0.001$). Based on a cohort analysis, Neylan *et al.* found that the qualification of morbidly obese and super obese patients (BMI > 50 kg/m^2) for open cholecystectomy was associated with a higher risk of death or severe complications (OR = 3.45; 95% CI: 2.16–5.50, $p < 0.001$). However, if conversion occurred, the treatment results were not worse than in the case of *a priori* scheduled open cholecystectomy [159].

5.2. We recommend laparoscopic cholecystectomy for acute cholecystitis within the first 72 h of symptom onset. This creates the most technically favorable operating conditions for the operation. Performing laparoscopic cholecystectomy after this time still brings benefits to the patient, but then the operation is usually technically more difficult, takes longer, and it is more often necessary to convert to the open method.

The developing inflammatory infiltrate accompanying acute cholecystitis increases the swelling and hyperemia of the tissues, and increases the fragility of the prepared structures, ultimately leading to their fibrosis [160]. These are the factors that increase the degree of difficulty of cholecystectomy [161, 162]. In addition, thickening of the gallbladder wall, the presence of a stone lodged in the neck of the gallbladder and persistently high CRP values in the blood serum are associated with longer operative time and more frequent conversions to the open method [163]. Ambe *et al.* found that conversion and complications occur more frequently in moderate and severe cholecystitis (grades II and III according to the *Tokyo Guidelines*) than in mild inflammation (grade I) [164]. The severity of inflammation is a dynamic process and increases over the next few days following onset of the ailment. Therefore, performing laparoscopic cholecystectomy as soon as possible after the onset of symptoms shortens the time of the operation and reduces the risk of conversion and complications. Many studies have shown that if cholecystectomy is performed within 72 h of the onset of symptoms, the difficulty of the operation is lower, the duration of the operation is shorter and fewer complications are observed [165, 166].

Performing laparoscopic cholecystectomy after 72 h from the onset of symptoms is still possible and safe, but it is associated with a greater degree of difficulty of the operation [167]. Roulin *et al.* found that performing laparoscopic cholecystectomy in this period is associated with a lower rate of complications, shorter hospitalization and lower treatment costs compared to surgery performed only 6 weeks after the onset of symptoms [168]. Similar conclusions were reached by Wu *et al.* in their meta-analysis, which showed that laparoscopic cholecystectomy performed within 7 days from the onset of symptoms was associated with a lower percentage of wound infections, greater patient satisfaction with the treatment, higher quality of life of the patient and shorter absence from work compared to surgery performed at least 1 week after the symptoms subsided. However, in the case of early cholecystectomy, the operation was longer and technically more difficult [169]. Hence, according to the guidelines of the World Society of Emergency Surgery of 2020, laparoscopic cholecystectomy should be performed within the first 7 days of

hospitalization, but not later than within 10 days from the onset of symptoms [148].

5.3. We recommend antibiotic prophylaxis prior to laparoscopic cholecystectomy for acute cholecystitis.

Many studies have been published on antibiotic prophylaxis in acute cholecystitis, but the results of these analyses are often contradictory due to the assessment of heterogeneous groups of patients [170]. In a systematic review of randomized studies, van Dijk *et al.* found no significant benefit from the use of antibiotic prophylaxis in this group of patients, but they noted the low quality of scientific evidence in the analyzed studies and the heterogeneity of patient groups [171]. Matsui *et al.* reviewed seven meta-analyses, in which, contrary to the currently established opinion, they clearly demonstrated the benefit of using antibiotic prophylaxis in low-risk cholecystectomy. A single administration of the antibiotic reduced the number of surgical site infections (RR = 0.71; 95% CI: 0.51–0.99) and other distant infections (RR = 0.37; 95% CI: 0.19–0.73) and the total number of infections (RR = 0.50; 95% CI: 0.34–0.75) [172]. Currently, it is emphasized that the use of prophylaxis should take into account not only the stage of cholecystitis, but also factors depending on the patient (e.g. age, coexisting diseases) and depending on the treatment center (infection rate) [173].

In a randomized controlled trial, Loozen *et al.* compared the effect of prolonged perioperative antibiotic prophylaxis (cefuroxime and metronidazole administered for 3 days after surgery) versus a single dose (cefazolin) on infection rates in patients after cholecystectomy for acute cholecystitis [174]. The authors found no differences between the two groups in the rate of infection within 30 days after surgery and concluded that a single dose of antibiotic is sufficient in this group of patients. Similar conclusions were reached by the authors of another analysis, which showed that in the case of mild or moderate cholecystitis, postoperative antibiotic therapy based on amoxicillin and clavulanic acid does not reduce the number of infections within 4 weeks after cholecystectomy [175]. These results were confirmed by a recent meta-analysis in which prolonged antibiotic therapy was found to be of no benefit [176]. Thus, in stages I and II of cholecystitis according to the criteria in the *Tokyo Guidelines*, there is no need for prolonged postoperative antibiotic therapy [177].

5.4. In the presence of choledocholithiasis, the decision on a two-stage treatment strategy (ERCP plus laparoscopic cholecystectomy) or a single-stage treatment strategy (laparoscopic cholecystectomy with biliary revision) should depend on the experience of the surgical team and the availability of an endoscopic laboratory.

Choledocholithiasis often coexists in patients with acute cholecystitis and, if left untreated, may lead to mechanical jaundice, cholangitis or acute pancreatitis. The incidence of choledocholithiasis is estimated at about 15% in patients with symptomatic cholelithiasis [178]. Among the patients diagnosed with ductal stones, approximately 2–3 will require intervention to remove the deposits, while in the rest they will evacuate spontaneously [179].

Choledocholithiasis is treated with ERCP or intraoperative revision of the extrahepatic bile ducts. The percentage of complete removal of deposits is comparable in both methods and is around 90% [180]. Based on a meta-analysis of 16 randomized clinical trials, Dasari *et al.* concluded that there are no significant differences in the incidence of complications and mortality between the use of ERCP and laparoscopic revision of the extrahepatic bile ducts in the treatment of choledocholithiasis [181].

Laparoscopic revision of the extrahepatic bile ducts can be performed via choledochotomy or via the cystic duct. Stones can be evacuated by rinsing with 0.9% NaCl solution, or using a Dormia basket or a Fogarty catheter. Intravenous administration of 1–2 mg of glucagon causes relaxation of the hepatopancreatic ampulla sphincter and may favor the evacuation of some deposits into the duodenum.

Simultaneous laparoscopic cholecystectomy with revision of the bile ducts is technically demanding and the decision to perform it should be made taking into account the experience of the operator, the availability of specialized equipment and the availability of an endoscopic laboratory. Simultaneous treatment extends the total time of surgery, but it allows the total time of hospitalization to be shortened, thus increasing the cost-effectiveness of this therapeutic strategy [182].

5.5. We recommend dissection of the area of the alveolar triangle taking into account the Critical View of Safety (CVS) criteria to reduce the risk of iatrogenic biliary injury during laparoscopic cholecystectomy for acute cholecystitis.

As a result of a significant increase in the incidence of iatrogenic biliary tract damage during cholecystectomy after laparoscopic access became popular, Strasberg *et al*. proposed the term "critical view of safety" as a method to identify the cystic duct and the cystic artery [183]. This is the stage of the operation which includes the dissection of the lower part of the gallbladder from its bed and the complete dissection of the cystohepatic triangle, in which there are two and only two tubular structures leading to the gallbladder. In the case of acute cholecystitis, inflammatory infiltration and adhesions in the dissected area may significantly hinder the initial identification of the cystohepatic triangle. In such a situation, the dissection should start not lower than at the level of the imaginary line connecting Rouvière's groove and the base of segment IV of the liver. CVS is the safest method of identifying structures in the cystohepatic triangle and effectively reduces the incidence of iatrogenic bile duct damage during laparoscopic cholecystectomy [184–189]. Indirect evidence of the effectiveness of CVS also comes from studies on large groups of patients with iatrogenic damage to the structures of the hepatoduodenal ligament, analyzing intraoperative management during cholecystectomy. Confirmation of compliance with the CVS principles was observed in only 0–6.3% of cases of laparoscopic cholecystectomy leading to this type of complication [190, 191].

5.6. We do not recommend reducing the number of trocars during laparoscopic cholecystectomy for acute cholecystitis.

The most favorable exposure of the alveolar-hepatic triangle can be obtained during retraction of the bottom of the gallbladder in the cranial direction with simultaneous retraction of the gallbladder in the area of its neck. For this purpose, the most effective method is to use 4 trocars during laparoscopic cholecystectomy. Reducing the number of trocars may make it more difficult to meet the CVS criteria, especially in acute cholecystitis, and thus increase the risk of iatrogenic biliary injury. Studies published to date focus on the comparison of 4-trocar access with single incision laparoscopic surgery (SILS), showing an incidence of iatrogenic biliary injury of 0.32–0.52% and 0.72% of cases, respectively [192, 193]. A meta-analysis of 24 randomized trials also points to an increased risk of severe complications (Clavien-Dindo > III) with the use of SILS compared to laparoscopic cholecystectomy with 4 trocars [194]. Potential benefits resulting from the reduction of the number of trocars used, such as a better cosmetic effect or lower need for analgesics in the postoperative period, do not offset the potential increase in the risk of iatrogenic bile duct damage or other severe postoperative complications.

5.7. We recommend conversion to an open method or subtotal cholecystectomy if CVS criteria cannot be met or intraoperative biliary imaging is unavailable.

The possibility of meeting the CVS criteria is observed even in 87–96% of laparoscopic cholecystectomies, but it should be noted that not all data refer to laparoscopic cholecystectomy in acute cholecystitis [188, 195, 196]. In the case of conditions preventing the achievement of CVS, the possibilities of intraoperative imaging of the biliary tract should be used. Intraoperative cholangiography allows one not only to learn about the anatomy of the bile ducts, but also to diagnose ductal stones [197]. Its use significantly reduces the risk of iatrogenic damage to the bile ducts, especially in patients with acute cholecystitis (OR = 0.44, 95% CI: 0.30–0.63) [198]. An alternative method of imaging the extrahepatic bile ducts is near-infrared fluorescence cholangiography [199, 200]. In case of difficulties in identifying the structures of the cystohepatic triangle, an intraoperative consultation of a second experienced surgeon should always be considered.

In the event of persistent difficulties in identifying structures in the cystohepatic triangle, emergency procedures should be undertaken. If the reason for not obtaining CVS is the inability to safely reach the area of Calot's triangle, conversion to laparotomy should be considered. In the absence of opportunities obtaining CVS resulting from the severity of lesions in the cystohepatic triangle itself, conversion to laparotomy *per se* does not increase the chances of full identification of significant structures, and subtotal cholecystectomy (Terblanche operation) should be considered to avoid iatrogenic damage to the structures of the hepatoduodenal ligament [184–186, 201–204]. The opening of the cystic duct to the follicle can be sutured, closed with a clip, or an Escat drain can be inserted. However, it should be noted that subtotal cholecystectomy increases the incidence of bile leakage from the cystic duct

stump, the need for reoperation and readmission to the hospital [203, 205, 206]. For this reason, such a procedure should be used only when other methods of identifying structures in the cystohepatic triangle have been exhausted and should be treated as a "damage control" strategy [207].

5.8. There is no clinical evidence for the benefit of routine drainage after cholecystectomy in acute cholecystitis.

Cirocchi *et al.* published a systematic review of 7 studies and 1274 patients. They concluded that acute cholecystitis is not an indication for routine drainage after laparoscopic cholecystectomy, but emphasize that each case should be considered individually [208]. Similar conclusions come from the meta-analysis conducted by Picchio *et al.* The authors conclude that prophylactic placement of drains does not bring benefits in reducing surgical complications, while unjustified insertion of drains prolongs the recovery period after surgery [209].

5.9. If iatrogenic damage to the bile ducts is found during laparoscopic cholecystectomy, we recommend drainage around the follicle bed (avoiding drainage of individual ducts). The patient with a detailed description of the operation (or video documentation) should be immediately transferred to a center experienced in biliary tract repair operations.

In the event of intraoperative suspicion of bile duct damage, intraoperative cholangiography is helpful in assessing the extent of damage [210, 211]. In the case of an unfavorable diagnosis, a suspicion of simultaneous damage to the vascular structures of the hepatoduodenal ligament should always be raised, which can be verified using intraoperative ultrasonography or postoperative computed tomography with contrast [212, 213]. There is no need to convert to laparotomy when the diagnosis can be made laparoscopically. Intraoperative management in centers without experience in biliary tract repair operations should consist in protecting the patient against biliary peritonitis by installing effective drainage of the abdominal cavity (drains 1. in the area of the hepatic hilum, 2. in the right lobe of the liver, and 3. in the minor pelvis). The assessment of the extent of damage should be based on imaging tests. It is not recommended to continue dissection in the area of the hepatic hilum in the absence of adequate experience to perform a simultaneous repair operation.

The patient with secured drainage and documentation describing the initial diagnosis of the extent of damage should be immediately transferred to a center experienced in biliary repair operations. An early attempt at repair by an inexperienced team is associated with significantly worse outcomes compared to delayed repair by a team experienced in this type of surgery [214, 215]. In addition, it is important not to delay the transfer of the patient to a center with appropriate experience in thirty biliary tract repair operations, as early transfer of the patient may reduce the risk of complications after repair operations as much as four-fold (OR = 0.24; 95% CI: 0.09–0.68, p = 0.007) [214].

Conclusions

Laparoscopy is the preferred method of surgical treatment in the emergency room, assuming the appropriate experience of the surgeon performing the operation and observing the safety rules, including the rules of conversion to laparotomy. The second part of the guidelines covers the following challenges for surgical practice: acute appendicitis, acute mesenteric ischemia, abdominal injuries, bowel obstruction, diverticulitis, laparoscopy in pregnancy and postoperative complications requiring an reoperation.

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