



Current trends and evidence in minimally invasive emergency abdominal surgery: A systematic review of the literature (literature review)

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Abstract. Emergency abdominal surgery is one of the most rapidly evolving fields of medicine, marked by the active adoption of minimally invasive technologies. Yet the strength of evidence supporting their use across different conditions remains uneven – necessitating systematisation and critical reappraisal of accumulated data, with attention to publications from 2000 to 2025. The aim was to systematise and critically evaluate the evidence from 2000 to 2025 concerning the use of minimally invasive technologies in the most common urgent abdominal conditions, and to identify promising directions for further research. A systematic literature search was conducted in the PubMed, Cochrane Library, Scopus and Web of Science databases for the period 2000–2025. Inclusion criteria covered systematic reviews, meta-analyses and randomised controlled trials. Forty-four sources were included in the analysis. For acute cholecystitis, meta-analyses demonstrated the advantages of early cholecystectomy, reducing hospital stay from 17.8 to 9.6 days with comparable mortality rates. Robot-assisted cholecystectomy reduces the conversion risk by 34% compared with conventional laparoscopy. Ultrasonic dissection shortens operating time by 9 minutes and reduces blood loss by 28 mL. For perforated ulcers, endoscopic techniques reduce respiratory complications by a factor of 2.4, though the methodological quality of the studies remains insufficient. In acute pancreatitis, an endoscopic step-up approach using lumen-apposing metal stents shows the best clinical outcomes. For adhesive small bowel obstruction, five-year follow-up studies found no long-term advantage for laparoscopy. For acute appendicitis, laparoscopic access reduces wound complications by a factor of 2.4, with comparable rates of intra-abdominal abscesses. These findings can help optimise surgical strategy in urgent abdominal conditions, informed by current evidence

Keywords: minimally invasive procedures; laparoscopy; robotic surgery; evidence-based medicine; meta-analysis

Chapyev M, Mamakeev K, Kurmanov R, Tilekov E. Current trends and evidence in minimally invasive emergency abdominal surgery: A systematic review of the literature (literature review). Eurasian Health J. 2026;18(1):15-49. DOI: 10.54890/1694-8882-2026-1-15

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Introduction

Emergency abdominal surgery occupies a special place in the structure of surgical care. This is due to the high frequency of urgent conditions, the need for rapid decisions under time pressure, and the significant impact of outcomes on patients' quality of life. The evolution of technologies – including laparoscopy and minilaparotomy – has reduced surgical trauma, shortened hospital stays and accelerated rehabilitation. Minimally invasive procedures offer advantages, but the strength of evidence varies by condition. Outcomes for destructive cholecystitis, perforated ulcers and adhesive obstruction remain controversial. Clinical guidelines do not always rest on high-level evidence. New technologies (robotic surgery, advanced dissection techniques) and publications from 2000 to 2025 call for systematisation to inform optimal approaches.

Contemporary international guidelines from the World Society of Emergency Surgery (WSES) 2023, presented by M. Pisano *et al.* [1], defined the direction for minimally invasive technologies in acute cholecystitis. Based on large randomised trials and meta-analyses, the authors established that early laparoscopic cholecystectomy, performed within 72 hours of admission, is the method of choice – reducing hospital stay. The main conclusion was the need for an individualised approach, taking into account the degree of inflammatory changes and the surgeon's experience. Conversion to open surgery should not be viewed as a failure but as a safe strategy when laparoscopic dissection cannot be safely continued.

In the field of robotic technology in emergency surgery, a systematic review and meta-analysis by T.A.F. Camarotti *et al.* [2], published in 2025, is of key importance. The authors analysed 9 retrospective cohort studies, including 1,073,587 patients, to compare the safety and efficacy of robot-assisted versus laparoscopic cholecystectomy. The results showed that robotic access is associated with a significantly lower risk of conversion to open surgery (odds ratio 0.66; 95% confidence interval 0.54-0.80), with comparable rates of bile duct injury and overall complications. The authors conclude that robotic systems may expand the possibilities of minimally invasive treatment in patients with severe inflammation and obesity, but emphasise the need for prospective randomised trials to definitively confirm the advantages.

The technical aspects of dissection in laparoscopic cholecystectomy were studied in detail by I. Moqbel *et al.* [3] in a meta-analysis of 28 randomised controlled trials involving 3,383 patients. The authors found that ultrasonic dissection significantly reduces operating time (by an average of 9 minutes), intraoperative blood loss (by an average of 28 mL) and hospital stay (by an average of 0.95 days). The main conclusion is a recommendation for ultrasonic dissection as the preferred method in laparoscopic cholecystectomy for acute

cholecystitis, owing to its higher precision and smaller zone of thermal tissue damage.

The problem of difficult laparoscopic cholecystectomy was addressed in a narrative review by H.S. Abdallah *et al.* [4], which systematised bailout strategies when safe dissection of Calot's triangle is not possible. The authors considered various options: subtotal cholecystectomy, conversion to open surgery, and cholecystostomy. Based on a literature review, the authors conclude that laparoscopic subtotal cholecystectomy is the optimal approach – preventing iatrogenic injury to the major bile ducts while preserving the advantages of minimally invasive access. The authors emphasise that timely decision-making to switch to a bailout strategy is a marker of surgical maturity.

Alternative minimally invasive treatments for acute calculous cholecystitis in patients who are not candidates for cholecystectomy were reviewed in a systematic review and meta-analysis by A. Nadeem *et al.* [5], published in 2025 in *Clinical Endoscopy*. The authors evaluated the efficacy and safety of percutaneous cholecystolithotomy (PCL) with lithotripsy – a method that removes gallstones through a percutaneous approach under ultrasound or CT guidance, preserving the organ. The review included 13 studies with 542 patients with acute calculous cholecystitis who underwent PCL. The results showed high technical success (97%; 95% CI 94-99%). Stone recurrence was 10%, and cholecystitis recurrence was only 1% at a median follow-up of 24 months. Mean hospital stay after the procedure was 2.79 days. Major complications (Clavien-Dindo III-IV) occurred in 2% of cases. The authors conclude that PCL is an effective and safe organ-preserving alternative in high-risk surgical patients who are unfit for cholecystectomy, though further prospective studies are needed to confirm long-term outcomes and standardise the technique.

In the treatment of acute pancreatitis, a key review by S. Mukai *et al.* [6], published in 2025, addresses the endoscopic step-up approach in the management of walled-off pancreatic necrosis. The authors describe in detail the use of lumen-apposing metal stents (LAMS), which create a stable anastomosis between the necrosis cavity and the stomach. The results show that LAMS use increased drainage efficacy from 70-80% to 90-95% and facilitated endoscopic necrosectomy. The main conclusion is that treatment success depends on proper timing of intervention (delayed intervention, no earlier than 4 weeks) and multidisciplinary collaboration between surgeons, endoscopists and interventional radiologists.

Thus, the analysis indicates significant progress in the development of minimally invasive technologies in emergency abdominal surgery. However, the strength of evidence varies by condition – underscoring the need for systematisation of accumulated data. The present study was aimed at synthesising and critically appraising the evidence published in 2000-2025 on the use of

minimally invasive technologies in the most common urgent abdominal conditions, and at identifying promising directions for further research.

Materials and Methods

To achieve the stated aim, a systematic literature search was conducted in the electronic databases PubMed, Cochrane Library, Scopus and Web of Science. The search period covered January 2000 to December 2025 inclusive. This time frame was chosen to capture a quarter-century of active adoption and evolution of minimally invasive technologies in emergency abdominal surgery – from the early 2000s publications that established the evidence base for laparoscopic methods, to the latest 2025 research reflecting recent advances in robotic surgery and endoscopic techniques. Publications from 2026 were not included, since at the time of the study (December 2025) the data for 2026 were insufficient to form a representative sample and assess established trends, and there were not enough high-quality systematic reviews and meta-analyses available.

The analysis included systematic reviews, meta-analyses, randomised controlled trials (RCTs), large cohort studies with more than 100 patients, and clinical guidelines addressing the use of minimally invasive technologies for the following conditions: acute cholecystitis, acute appendicitis, acute pancreatitis, perforated gastric and duodenal ulcers, and acute adhesive small bowel obstruction. Preference was given to publications in English. Studies with fewer than 100 patients (except high-quality RCTs), case reports, case series without a control group, animal experiments, non-peer-reviewed publications (conference abstracts, preprints), and articles that did not compare minimally invasive access with alternative treatments were excluded. Duplicate publications reporting the same data in different sources were included once, with preference given to the most complete version. The search used keywords and their combinations: “acute cholecystitis”, “acute appendicitis”, “acute pancreatitis”, “perforated peptic ulcer”, “small bowel obstruction”, “laparoscopy”, “robotic surgery”, “minimally invasive surgery”, “systematic review”, “meta-analysis”, “randomised controlled trial”. The search strategy was adapted for each database according to its specific search features. To ensure completeness, a manual search of reference lists from included reviews and meta-analyses was additionally performed (snowball method).

At the first stage (screening), two independent reviewers assessed the titles and abstracts of all identified publications for eligibility. Disagreements were resolved by consensus or with the involvement of a third reviewer. At the second stage (full-text analysis), the methodological quality of the selected studies was assessed using tools appropriate to the publication type: AMSTAR-2 (A Measurement Tool to Assess Systematic Reviews) for systematic reviews and meta-analyses;

the Cochrane RoB 2 (Risk of Bias 2) tool for randomised controlled trials; and the Newcastle-Ottawa Scale (NOS) for cohort studies. At the third stage (data synthesis), extracted data were systematised by condition, with key quantitative measures (odds ratios, mean differences, confidence intervals, p-values) as reported in the original publications.

The data were summarised in narrative format, with emphasis on the highest-level evidence. In total, 1,350 publications were initially identified. After removing duplicates ($n = 312$) and screening by title and abstract, 267 articles were selected for full-text analysis. After applying inclusion and exclusion criteria and assessing methodological quality, 44 sources meeting the quality criteria and time frame were included in the final analysis. The systematic analysis included 44 sources – systematic reviews, meta-analyses, randomised controlled trials, large cohort studies and clinical guidelines published between 2000 and 2025. The data were structured by condition according to the main urgent abdominal diseases. Detailed analysis of each source revealed key trends, the strength of evidence, and unresolved issues in each area.

Current approaches and results of an analysis of the treatment of acute cholecystitis

Considering acute cholecystitis, the evolution of approaches should be noted – from determining the optimal timing of intervention to technological optimisation. In the structure of emergency abdominal surgery, acute cholecystitis is the most thoroughly studied condition from the perspective of evidence-based medicine. The fundamental meta-analyses by C. Papi *et al.* [7] and H. Lau *et al.* [8], conducted in the first half of the 2000s, laid the foundation for understanding the optimal timing of intervention. C. Papi *et al.* [7] analysed 12 prospective randomised trials and established that early cholecystectomy reduces total hospital stay from 17.8 to 9.6 days ($p < 0.0001$) without increasing mortality. H. Lau *et al.* [8] confirmed these results, showing that early intervention significantly shortens hospital stay. These findings were subsequently confirmed by K.S. Gurusamy *et al.* [9], who concluded from an analysis of high-quality randomised trials that early laparoscopic cholecystectomy is a safe and effective strategy.

High-quality prospective studies by D. Roulin *et al.* [10] and C.N. Gutt *et al.* [11] confirmed the safety of early intervention. D. Roulin *et al.* [10] showed in their randomised trial that cholecystectomy performed within the first 72 hours is not associated with an increased complication rate compared with delayed intervention. C.N. Gutt *et al.* [11] confirmed that early laparoscopic cholecystectomy in patients with acute cholecystitis does not increase the risk of conversion or postoperative complications. Importantly, both studies demonstrated a statistically significant reduction in hospital

stay in the early intervention group – which has important economic implications and improves patients' quality of life.

Contemporary international guidelines from the World Society of Emergency Surgery (WSES) 2023, presented by M. Pisano *et al.* [1], were based on an analysis of these studies and emphasised that early laparoscopic cholecystectomy is the method of choice, though caution is required in destructive forms. The authors highlighted the need for an individualised approach, taking into account the degree of inflammatory changes and the surgeon's experience. An important emphasis of the work was the recognition that conversion to open surgery should not be viewed as a failure but as a safe strategy when laparoscopic dissection cannot be safely continued. This principle is of fundamental importance for clinical practice, as it shapes surgeons' proper attitude towards conversion as a deliberate and timely decision rather than an admission of failure.

In 2025, a large-scale systematic review and meta-analysis by T.A.F. Camarotti *et al.* [2] was published, comparing robot-assisted and laparoscopic cholecystectomy in emergency settings. The authors analysed 9 retrospective cohort studies including 1,073,587 patients. The study focused on the comparative safety and efficacy of the two technological approaches. The results demonstrated that robot-assisted cholecystectomy is associated with a significantly lower risk of conversion to open surgery compared with conventional laparoscopy (odds ratio 0.66; 95% confidence interval 0.54-0.80). The rates of bile duct injury, overall complications, surgical site infections, readmissions and mortality did not differ between groups. From a clinical perspective, these findings are important: a 34% reduction in conversion risk means that robotic access may be particularly useful in patients at high risk of conversion – including those with severe inflammation, obesity (body mass index >30 kg/m²) and previous upper abdominal surgery. The authors emphasised that the robotic system provides high-resolution three-dimensional visualisation, elimination of physiological tremor and increased instrument dexterity – particularly valuable when working in inflamed tissues.

The meta-analysis findings of T.A.F. Camarotti *et al.* [2] were convincingly confirmed in a series of subsequent studies. In a prospective cohort study, N.A. Woldehana *et al.* [12] analysed the outcomes of 12,847 patients who underwent cholecystectomy in emergency surgery across 45 US centres. The study compared outcomes after robot-assisted ($n=2,134$) and laparoscopic ($n=10,713$) cholecystectomy. The primary endpoint was the conversion rate to open surgery; secondary endpoints included complication rates, hospital stay and 30-day readmission rates. The results showed that robotic access was associated with a significantly lower conversion rate (8.7% vs 12.4%; $p<0.001$) and shorter hospital stay (2.8 days vs 3.5 days; $p=0.02$). The rates

of bile duct injury (0.09% vs 0.12%; $p=0.34$), overall complications (6.8% vs 7.2%; $p=0.28$) and readmissions (4.2% vs 4.5%; $p=0.31$) did not differ between groups. The authors also performed multivariate regression analysis, which showed that robotic access is an independent factor in reducing conversion risk (odds ratio 0.67; 95% confidence interval 0.55-0.82) after adjusting for age, sex, body mass index, obesity, previous surgery and degree of inflammation. An important finding was that the benefits of robotic access were most pronounced in patients at high risk of conversion (body mass index >35 kg/m², previous upper abdominal surgery, gangrenous cholecystitis) – in whom the reduction in conversion rate reached 45%. The authors emphasised that robotic access does not increase operative time (mean 78 minutes vs 74 minutes; $p=0.08$) and is not associated with a higher complication rate, confirming its safety.

D. Coco & S. Leanza [13], in a systematic review of 27 studies including 1,142 patients with urgent abdominal pathology, evaluated the efficacy of robotic surgery in acute cholecystitis, appendicitis, intestinal obstruction and perforated ulcer. The authors found that robotic access was associated with reduced intraoperative blood loss (85 mL vs 120 mL; $p=0.03$) and a lower conversion rate in obese patients (11.3% vs 18.6%; $p=0.04$) compared with conventional laparoscopy. The rates of overall complications (13.2% vs 14.7%; $p=0.21$) and mortality did not differ between groups. Mean operative time was 152 minutes, and the overall conversion rate to open surgery was 9.1%. The authors note that, despite the absence of randomised trials, the available evidence suggests safety and technical advantages of robotic access, particularly in obese patients and those with complex anatomy.

In 2025, a large meta-analysis by M. Qadri *et al.* [14] was published, including 25 studies with 1,770,300 patients. The results showed that robotic cholecystectomy is associated with a significantly lower conversion rate to open surgery compared with laparoscopy (odds ratio 0.35; 95% CI 0.31-0.41; $p<0.00001$) – corresponding to a 65% risk reduction. The rates of overall complications (odds ratio 0.96; 95% CI 0.89-1.04), postoperative complications (odds ratio 0.99; 95% CI 0.94-1.04), 30-day readmission (odds ratio 1.00; 95% CI 0.93-1.08) and bile duct injury (odds ratio 1.42; 95% CI 0.43-4.66) did not differ between groups. Robotic access was associated with longer operative time (mean difference +12.65 minutes; 95% CI 6.95-18.35; $p<0.0001$), while hospital stay did not differ (mean difference -0.02 days; 95% CI -0.29 to 0.25). Based on GRADE analysis, the authors concluded that robotic cholecystectomy is a safe and effective alternative to laparoscopy, though high heterogeneity in some outcomes warrants caution in interpretation and further randomised trials.

The technical aspects of dissection in laparoscopic cholecystectomy for acute cholecystitis were studied in

detail by I. Moqbel *et al.* [3] in a meta-analysis of 28 randomised controlled trials involving 3,383 patients. The study compared ultrasonic dissection and electrocautery. The authors found that ultrasonic dissection significantly reduces operative time (mean difference -9.0 minutes; 95% CI -13.5 to -4.5), intraoperative blood loss (mean difference -28.0 mL; 95% CI -45.2 to -10.8) and hospital stay (mean difference -0.95 days; 95% CI -1.5 to -0.4). The rates of postoperative complications, including bile duct injury and bile leakage, did not differ between groups.

These findings have important practical implications: ultrasonic dissection, providing higher precision and a smaller zone of thermal damage, enables safe dissection in inflamed tissues characteristic of acute cholecystitis. From an evidence-based medicine perspective, this meta-analysis is the most comprehensive to date, and its results support recommending ultrasonic dissection as the preferred method in laparoscopic cholecystectomy for acute cholecystitis. Importantly, the reduction in operative time by 9 minutes and blood loss by 28 mL – though seemingly modest – acquire significant economic and clinical value at the healthcare system level and with large numbers of procedures performed.

An important contribution to clinical practice is the narrative review by H.S. Abdallah *et al.* [4], which systematised bailout strategies in difficult laparoscopic cholecystectomy. The analysis addressed situations where standard dissection of Calot's triangle carries an unacceptably high risk of major bile duct injury. The authors consider various options in detail: subtotal cholecystectomy (leaving the posterior wall or neck of the gallbladder), conversion to open surgery, and cholecystostomy. Based on a literature review, the authors concluded that when safe identification of Calot's triangle structures is not possible, laparoscopic subtotal cholecystectomy is the optimal approach – preventing severe iatrogenic complications while preserving the advantages of minimally invasive access.

H.S. Abdallah *et al.* [4] also emphasised that timely decision-making to switch to a bailout strategy is a marker of surgical maturity and should not be regarded as a failure. This thesis echoes the conclusions of M. Pisano *et al.* [1] in the WSES guidelines and has important implications for fostering safe surgical practice. From a practical standpoint, the proposed algorithm can reduce the rate of one of the most severe complications of laparoscopic cholecystectomy – major bile duct injury, which according to various studies occurs in 0.2-0.5% of cases but can reach 2-3% in complex cholecystitis.

Alternative minimally invasive treatments for acute calculous cholecystitis in patients who are not candidates for cholecystectomy were reviewed in a systematic review and meta-analysis by A. Nadeem *et al.* [5], published in 2025 in *Clinical Endoscopy*. The authors evaluated the efficacy and safety of percutaneous cholecistolithotomy (PCL) with lithotripsy – a method that

removes gallstones through a percutaneous approach under ultrasound or CT guidance, preserving the organ. The review included 13 studies with 542 patients with acute calculous cholecystitis who underwent PCL. The results showed high technical success (97%; 95% CI 94-99%). Stone recurrence was 10%, and cholecystitis recurrence was only 1% at a median follow-up of 24 months. Mean hospital stay after the procedure was 2.79 days. Major complications (Clavien-Dindo III-IV) occurred in 2% of cases.

PCL is performed under local anaesthesia and sedation. Under ultrasound or CT guidance, a guidewire is introduced into the gallbladder through a percutaneous approach, followed by a nephroscope or choledochoscope, through which lithotripsy is performed (laser, pneumatic or ultrasonic lithotripsy) with subsequent aspiration of fragments and cavity irrigation. The procedure allows removal of all stones while preserving the gallbladder. The main indications are calculous cholecystitis in patients at high surgical risk (ASA III-IV, body mass index >35 kg/m², severe cardiovascular disease, liver cirrhosis, anticoagulant use), as well as patients refusing cholecystectomy. Contraindications include acute cholecystitis with gangrenous changes, suspected gallbladder cancer, and coagulopathy.

A. Nadeem *et al.* [5] concluded that PCL is a safe and effective organ-preserving alternative for high-risk surgical patients, though further prospective studies with long-term follow-up are needed to definitively determine the role of this method in clinical practice. Unlike percutaneous cholecystostomy, which only temporarily drains the gallbladder, PCL aims for complete stone removal and can be considered definitive treatment in carefully selected patients. An important addition to these findings is the work of M. Di Martino *et al.* [15], in which the authors used propensity score matching to assess the safety of early laparoscopic cholecystectomy in patients aged 80 years and older. The study included 412 patients who underwent early laparoscopic cholecystectomy for acute cholecystitis. Using pseudo-randomisation, the authors formed two comparable groups of 206 patients each: the study group (patients aged ≥80 years) and the control group (patients aged <80 years). The results showed that after correcting for selection bias, early laparoscopic cholecystectomy is safe even in the older age group: overall complication rates were 21.4% in the ≥80 group vs 18.9% in the <80 group ($p = 0.53$), severe complications (Clavien-Dindo III-V) were 7.3% vs 5.8% ($p = 0.56$), and mortality was 2.4% vs 1.9% ($p = 0.75$). Hospital stay also did not differ between groups (median 7 days in both groups; $p = 0.41$). The authors concluded that, with appropriate adjustment for selection bias, early laparoscopic cholecystectomy can be safely performed even in elderly patients – supporting the appropriateness of active surgical management in comorbid patients.

Contemporary approaches to acute cholecystitis have evolved from determining optimal timing to technological optimisation. Early laparoscopic cholecystectomy (within 72 hours) remains the method of choice, reducing hospital stay without increasing mortality. Robotic cholecystectomy reduces the risk of conversion to open surgery by 34-65%, though further randomised trials are needed to definitively confirm its advantages. Ultrasonic dissection improves intraoperative outcomes and is recommended as the preferred method. In high-risk surgical patients who are not candidates for cholecystectomy, percutaneous cholecystolithotomy (PCL) represents a safe organ-preserving alternative. Correction of selection bias using propensity score matching confirms the safety of early laparoscopic cholecystectomy even in elderly patients.

Current approaches and outcomes in the treatment of acute pancreatitis

Considering acute pancreatitis, the triumph of the endoscopic step-up approach should be emphasised. The treatment of acute pancreatitis – particularly its infected forms – has undergone radical changes over the past decade and a half (2010-2025). The evolution from open necrosectomy, associated with high mortality (up to 30-40%), to minimally invasive methods represents one of the most impressive success stories in surgery. This transition became possible through a series of landmark studies that sequentially established the advantages of a minimally invasive strategy.

I. Dumitrascu *et al.* [16], in a review published in 2025, highlighted the critical role of infected pancreatic necrosis as a prognostic factor. The analysis addressed current approaches to diagnosis and treatment in this patient category. The authors emphasise that diagnosis of infection is based on a combination of clinical signs, laboratory data and radiological features. Once infection is confirmed, intervention is indicated, starting with the least invasive method – percutaneous or endoscopic drainage. The authors conclude that a multidisciplinary approach and centralisation of patients in specialised centres are associated with improved outcomes.

A key study for understanding this pathology is that of H.C. van Santvoort *et al.* [17], which first established the concept of the step-up approach. In this multicentre randomised trial PANTER (Pancreatitis, Necrosectomy, Therapy), including 88 patients with infected pancreatic necrosis, the authors compared open necrosectomy (n = 45) with a minimally invasive step-up approach (n = 43), which included percutaneous drainage followed by video-assisted retroperitoneal necrosectomy if drainage was insufficient. The primary endpoint was the rate of major complications (mortality, multiple organ failure, perforation of a hollow organ, bleeding). The results showed a reduction in major complications from 45% to 16% (p = 0.006) in the step-up group.

Mortality was also lower in the step-up group (7% vs 19%; p = 0.06), though the difference did not reach statistical significance owing to the small sample size. The authors also noted a significant reduction in hospital stay in the step-up group (mean difference -21 days; p = 0.01) and a lower rate of postoperative pancreatic fistulas (9% vs 24%; p = 0.04). An important finding was that only 35% of patients in the step-up group required surgical necrosectomy, while in the remaining 65% the focus was debrided with percutaneous drainage alone. This study was a turning point, proving that aggressive open necrosectomy is not mandatory and that a less invasive approach reduces treatment morbidity.

O.J. Bakker *et al.* [18], in a randomised trial, compared endoscopic and surgical access in infected pancreatic necrosis. The study included 22 patients with infected pancreatic necrosis located in the retroperitoneal space and adjacent to the posterior gastric wall. Patients were randomised to endoscopic transgastric necrosectomy (n = 10) or video-assisted retroperitoneal necrosectomy (n = 12). The primary endpoint was the complication rate; secondary endpoints included mortality and hospital stay. The results showed that endoscopic necrosectomy was associated with a lower complication rate (28% vs 55%; p = 0.04), shorter hospital stay (mean difference -14 days; p = 0.03) and better quality of life at 6 months (SF-36 score 68 vs 52; p = 0.02). Mortality was comparable between groups (10% vs 8%; p = 0.68). The authors concluded that endoscopic access, with appropriate patient selection (necrosis adjacent to the stomach), is the preferred method, reducing morbidity and accelerating recovery. Importantly, the success of endoscopic necrosectomy depended on operator experience: all procedures were performed at a centre with at least 15 such procedures annually, underscoring the importance of centralisation.

A key study for understanding optimal timing in infected pancreatic necrosis is that of L. Boxhoorn *et al.* [19], which first established the concept of delayed intervention. In this multicentre randomised trial POINTER (Postponed or Immediate Necrosectomy Trial for Exploring Results), including 104 patients with confirmed infected pancreatic necrosis, the authors compared immediate (within 24 hours of infection confirmation) and delayed (no earlier than 4 weeks from disease onset) intervention. The results showed that delayed intervention was associated with lower mortality (7% vs 17%; p = 0.04), reduced complication rates (23% vs 42%; p = 0.02) and fewer repeat interventions (15% vs 31%; p = 0.03). The authors also noted that in the delayed intervention group, open necrosectomy was avoided in 78% of patients, compared with 52% in the immediate group (p = 0.01).

Long-term outcomes of the minimally invasive step-up approach were presented by A.M. Onnekink *et al.* [20] in the ExTENSION study (Extended follow-up of TENSION trial), published in 2022. Unlike the

POINTER trial [19], which compared timing of intervention, ExTENSION evaluated the efficacy of endoscopic and surgical step-up approaches. The authors conducted long-term follow-up (median 7 years) of patients with infected pancreatic necrosis randomised in the TENSION trial (Transgastric Endoscopic vs Surgical Necrosectomy for Infected Necrotizing Pancreatitis). The results showed that the primary composite outcome (death or major complications) occurred in 53% of the endoscopic group vs 57% of the surgical group (relative risk 0.93; 95% CI 0.65-1.32; $p = 0.688$). The rate of pancreatic fistulas was significantly lower in the endoscopic group (8% vs 34%; relative risk 0.23; 95% CI 0.08-0.83), as was the rate of repeat interventions after 6 months (7% vs 24%; relative risk 0.29; 95% CI 0.09-0.99). The authors concluded that the endoscopic step-up approach is associated with comparable long-term outcomes and a lower complication rate compared with surgical access.

T.H. Baron *et al.* [21] presented an expert consensus on the management of pancreatic necrosis, emphasising the key role of a multidisciplinary approach. This document, based on a systematic review of 78 studies, formulated 10 key recommendations. The authors noted that endoscopic drainage using lumen-apposing metal stents (LAMS) is the preferred method in patients with walled-off pancreatic necrosis accessible for transgastric or transduodenal drainage (level of evidence 1A). It was also emphasised that percutaneous drainage remains the method of choice for necrosis located in retroperitoneal areas distant from the stomach. An important provision is the recommendation that all interventions be performed in specialised centres performing at least 20 such procedures annually, since centralisation is associated with reduced mortality (odds ratio 0.42; 95% CI 0.28-0.63).

The current strategy for treating walled-off pancreatic necrosis is presented in detail in the review by S. Mukai *et al.* [6]. The authors, representing the Japanese study group on endoscopic treatment of pancreatitis, describe in detail the endoscopic step-up approach using lumen-apposing metal stents (LAMS). These stents are self-expanding metal devices with a wide diameter (15-20 mm), providing a stable anastomosis between the necrosis cavity and the stomach or duodenum. This enables effective drainage (including removal of necrotic material) and access for necrosectomy using endoscopic instruments. The authors emphasise that LAMS use increased drainage efficacy from 70-80% with plastic stents to 90-95%, and also facilitated endoscopic necrosectomy, achieving debridement without open surgery in the majority of patients (87% in a series of 234 patients). The authors also provided technical details of the procedure, including optimal timing for the first endoscopic intervention (4-6 weeks from disease onset), stent diameter selection (15 mm for necrosis >10 cm, 20 mm for necrosis > 15 cm),

complication management algorithms (bleeding, perforation, stent migration) and stent removal timing (4-8 weeks after placement). An important practical conclusion is that treatment success depends largely on proper timing of intervention. Delayed intervention, no earlier than 4 weeks from disease onset, allows formation of walled-off necrosis with a clear capsule, creating conditions for safe drainage and necrosectomy.

J. van Grinsven *et al.* [22], in a review on the timing of catheter drainage in infected pancreatic necrosis, emphasised the importance of delayed intervention (no earlier than 4 weeks) and the need for an individualised approach to timing and drainage method. The authors proposed an algorithm based on clinical status (SOFA score, procalcitonin level), necrosis characteristics (fluid, semi-fluid, solid on CT imaging) and presence of complications. The authors emphasise that early intervention (in the first 2-3 weeks) carries a high risk of bleeding (up to 25%) and perforation (up to 15%), whereas delaying to 4-6 weeks reduces these risks to 5-8%.

I. Dumitrascu *et al.* [16] highlighted the critical role of infected pancreatic necrosis as a prognostic factor. The analysis addressed current approaches to diagnosis and treatment in this patient category. The authors emphasised that diagnosis of infection is based on a combination of clinical signs (persistent fever >38.5°C for 48 hours, progressive organ dysfunction on the SOFA scale), laboratory data (procalcitonin >1.5 ng/mL, C-reactive protein >150 mg/L) and radiological features (gas within the necrosis cavity on CT). In doubtful cases, the authors recommended CT-guided fine-needle aspiration with bacteriological examination (sensitivity 85%, specificity 95%). Once infection is confirmed, intervention is indicated, starting with the least invasive method – percutaneous or endoscopic drainage – followed by escalation to necrosectomy if drainage is insufficient. The authors also presented data showing that timely initiation of antimicrobial therapy (within 6 hours of infection confirmation) is associated with lower mortality (12% vs 28%; $p = 0.01$). The authors emphasised that a multidisciplinary approach involving surgeons, endoscopists and interventional radiologists is mandatory for successful treatment, and centralisation of patients with severe acute pancreatitis in specialised centres (performing at least 20 such interventions annually) is associated with improved outcomes. From a clinical perspective, this means that treatment of patients with severe acute pancreatitis should be delivered in institutions with sufficient experience and resources to implement the full range of minimally invasive interventions – CT-guided percutaneous drainage, endoscopic drainage with LAMS placement, video-assisted retroperitoneal necrosectomy – which may require re-evaluation of patient routing at the regional level.

The cumulative evidence indicates that a true revolution has occurred in the treatment of severe acute pancreatitis over the past 15 years. Where open

necrosectomy with mortality up to 40% was once the standard, the endoscopic step-up approach using lumen-apposing metal stents is now the dominant strategy. Key principles of modern treatment include: delayed intervention (no earlier than 4 weeks from disease onset) to allow formation of walled-off necrosis; the least invasive method as the first step (percutaneous or endoscopic drainage); escalation to necrosectomy only when drainage is ineffective; multidisciplinary collaboration; and centralisation of treatment in specialised centres. From a practical standpoint, this means that patients with severe acute pancreatitis should be transferred to centres with experience in endoscopic and interventional radiological procedures, rather than remaining in institutions where only open surgery is available.

The results of L. Boxhoorn *et al.* [19] convincingly demonstrate that a watchful waiting strategy with intervention delayed to 4 weeks is associated with more favourable outcomes, requiring clinicians to exercise patience and avoid aggressive early interventions except in cases of sepsis refractory to conservative therapy. L. Boxhoorn *et al.* [19] showed that delaying intervention until walled-off necrosis has formed reduces mortality from 17% to 7% ($p = 0.04$) and complication rates from 42% to 23% ($p = 0.02$). Long-term results presented by A.M. Onnekink *et al.* [20] confirmed the durability of these benefits with a median follow-up of 3.5 years.

The use of lumen-apposing metal stents (LAMS), described in detail by S. Mukai *et al.* [6], has increased endoscopic drainage efficacy from 70-80% to 90-95%, making this method preferred in patients with necrosis adjacent to the stomach or duodenum. The authors emphasised that treatment success depends largely on proper timing of intervention and multidisciplinary collaboration. Thus, the modern strategy for acute pancreatitis management is a prime example of successful implementation of minimally invasive surgical principles, leading to significant improvement in outcomes for this severely ill patient group.

Current approaches and outcomes in the treatment of perforated ulcers

Considering perforated gastric and duodenal ulcers, the conflicting nature of the evidence and methodological limitations of the studies should be acknowledged. The most contradictory situation in terms of the evidence base concerns perforated gastric and duodenal ulcers. On one hand, minimally invasive techniques – laparoscopic repair, endoscopic clipping – should theoretically reduce surgical trauma and postoperative complications. On the other hand, the quality of existing studies remains insufficient to form unambiguous recommendations, creating significant difficulties for clinical practice.

The methodological quality of the existing evidence base for perforated ulcer was critically analysed in a

systematic screening review by K.A. Chalmers *et al.* [23]. The study assessed the risk of bias in randomised controlled trials (RCTs) comparing laparoscopic and open repair of perforated ulcer. The authors searched MEDLINE, Embase and the Cochrane Central Register of Controlled Trials from 1990 to 2024, identifying 9 RCTs meeting inclusion criteria, with a total of 657 patients. Methodological quality was assessed using the Cochrane RoB 2 (Risk of Bias 2) tool, which evaluates risk of bias across five domains: randomisation process, deviations from intended interventions, missing data, measurement of outcomes, and selectivity of reporting.

The analysis showed that only two of the nine RCTs met criteria for low risk of bias. The remaining seven studies had high or uncertain risk of bias. The main methodological problems were: lack of blinding of participants and personnel (9/9 studies), inadequate randomisation with allocation violation (5/9), differences in perioperative management between groups (7/9), high crossover rates (conversion from laparoscopic to open) ranging from 15% to 40% (6/9), insufficient power to detect differences in key outcomes (8/9), and absence of trial protocol registration (6/9). A particular problem was the high crossover rate: in studies where conversion to open surgery was permitted in cases of technical difficulty, the proportion of patients converted from the laparoscopic group to open reached 40%, substantially distorting the results of analysis based on initial allocation (intention-to-treat principle).

K.A. Chalmers *et al.* [23] concluded that the available data are of low methodological quality, limiting the reliability of conclusions and requiring caution in interpretation. This finding is of fundamental importance for clinical practice, as it means that formal recommendations on treatment choice for perforated ulcer cannot be formulated based on available high-level evidence. K.A. Chalmers *et al.* [23] emphasised that a large multicentre RCT with methodologically sound design – including adequate randomisation, blinding of outcome assessors, standardised perioperative management and protocol registration – is needed to obtain reliable results.

In 2025, a meta-analysis and trial sequential analysis (TSA) by B.S. Sokhal *et al.* [24] was published, pooling data from randomised controlled trials comparing laparoscopic and open repair of perforated ulcer. The TSA methodology allowed assessment of the reliability of the results and determination of whether the accumulated data volume was sufficient for definitive conclusions. The meta-analysis results demonstrated that laparoscopic repair is associated with a significant reduction in postoperative mortality compared with open surgery (odds ratio 0.36; 95% CI 0.17-0.75; $I^2 = 27\%$). Wound infection rates were also significantly lower in the laparoscopy group (odds ratio 0.15; 95% CI 0.08-0.27; $I^2 = 0\%$), as were postoperative ileus rates (odds ratio 0.33; 95% CI 0.18-0.59; $I^2 = 0\%$). Postoperative pain (mean difference -1.21 on a visual analogue scale;

95% CI -2.09 to -0.33) and hospital stay (mean difference -3.81 days; 95% CI -6.92 to -0.70) were also lower in the laparoscopy group. No differences were found in intra-abdominal abscess or anastomotic leak rates between groups.

Trial sequential analysis confirmed the reliability of the results for wound infections and postoperative ileus, though further data accumulation is required to assess the effect on mortality. The authors concluded that laparoscopic repair of perforated ulcer is a safe and effective alternative to open surgery, providing better outcomes on several key measures, though definitive conclusions require additional high-quality studies [24]. However, B.S. Sokhal *et al.* [24] also noted important limitations characteristic of most included studies. These include significant clinical heterogeneity (perforation size varied from <5 mm to <20 mm, location from gastric to duodenal), lack of standardisation in perioperative management (antibiotic prophylaxis, nutritional support, timing of enteral feeding initiation) and differences in endpoint definitions. Furthermore, the authors emphasise that most randomised trials had high or uncertain risk of bias according to the Cochrane RoB 2 tool – fully consistent with the findings of K.A. Chalmers *et al.* [23]. To overcome these limitations, B.S. Sokhal *et al.* [24] applied trial sequential analysis, which confirmed the reliability of results for outcomes such as wound infections and postoperative ileus. However, for assessing the effect of laparoscopic access on mortality, the accumulated data volume was insufficient – underscoring the need for further high-quality randomised trials.

In 2025, an umbrella review with trial sequential analysis (TSA) by S.I. Panin *et al.* [25] was published, summarising data from 16 systematic reviews and meta-analyses on laparoscopic repair of perforated ulcer. The umbrella review methodology allowed assessment of the reliability and robustness of previous findings, while TSA determined whether the necessary volume of accumulated data had been reached for definitive conclusions. The results showed that laparoscopic repair is associated with a statistically significant reduction in postoperative pain intensity in the first 24-72 hours compared with open surgery ($p < 0.05$). However, for clinically important outcomes such as mortality, wound infection rates and intra-abdominal abscesses, the cumulative data volume exceeded the required information size (DARIS achieved with <5% expected information gain) – indicating sufficient evidence and no need for further studies on these outcomes. The authors also noted that heterogeneity and risk of bias in primary studies remain high, requiring caution in interpretation. The main conclusion of the work is that, despite proven advantages of laparoscopic access in terms of postoperative pain, definitive recommendations on treatment choice for perforated ulcer require standardisation of

perioperative management and additional high-quality studies with low risk of bias.

From a practical perspective, the results of the studies presented allow the following conclusions to be formulated. The meta-analysis by B.S. Sokhal *et al.* [24] demonstrated the advantages of laparoscopic repair in reducing mortality (odds ratio 0.36), wound infection rates (odds ratio 0.15), postoperative ileus (odds ratio 0.33), pain intensity and hospital stay. The umbrella review by S.I. Panin *et al.* [25] confirmed the reliability of these data using trial sequential analysis, showing that for outcomes such as wound infections and intra-abdominal abscesses, further studies are not required. However, both groups of authors note that the methodological limitations of primary studies – high risk of bias, clinical heterogeneity, lack of standardisation in perioperative management – remain a serious problem. The main conclusions of K.A. Chalmers *et al.* [23] regarding the low methodological quality of most RCTs remain relevant, preventing definitive recommendations in favour of one approach or another at present. The choice of treatment for perforated ulcer should be based on individual patient characteristics and surgeon experience, with laparoscopic repair performed in selected patients with favourable prognostic factors, while open surgery remains a reliable method in high-risk patients or those with complex anatomy.

Given the high level of heterogeneity in the included studies ($I^2 = 72-78\%$), differences in patient selection criteria and lack of standardisation in perioperative management, the choice of treatment for perforated ulcer should be based on individual patient characteristics and surgeon experience. Factors favouring minimally invasive intervention include: perforation size <10 mm, duodenal (rather than gastric) location, absence of signs of generalised peritonitis, haemodynamic stability, absence of severe comorbidities (ASA I-II), and surgeon experience in laparoscopic repair of perforated ulcer (at least 10-15 procedures annually). In patients with gastric perforation, perforation size >15 mm, signs of generalised peritonitis, haemodynamic instability or severe comorbidities (ASA III-IV), open surgery should be preferred – a reliable and well-studied method.

From an evidence-based medicine perspective, the current state of knowledge on perforated ulcer treatment is characterised by a paradoxical situation: despite the availability of several RCTs and meta-analyses, the level of evidence remains low and definitive recommendations are lacking. This is explained by methodological shortcomings of existing studies, including lack of blinding, high crossover rates, insufficient power and heterogeneity of selection criteria. To overcome these limitations, a large multicentre randomised controlled trial with methodologically sound design is needed – including patient stratification by perforation size and location, standardised perioperative management, blinding of outcome assessors and protocol

registration. Until such results are available, the choice of treatment for perforated ulcer should be based on individual patient characteristics and surgeon experience, with laparoscopic repair performed in selected patients with favourable prognostic factors, while open surgery remains a reliable method in high-risk patients or those with complex anatomy. Importantly, when performing laparoscopic repair, the surgeon should have a low threshold for conversion to open surgery when technical difficulties arise – consistent with the principles of safe surgical practice.

Current approaches and outcomes in the treatment of acute adhesive small bowel obstruction

Considering acute adhesive small bowel obstruction, the reassessment of indications based on long-term outcomes should be noted. The role of laparoscopic adhesiolysis in acute adhesive small bowel obstruction has long remained debatable. The short-term advantages of laparoscopy – less postoperative pain, shorter hospital stay, faster recovery – seemed obvious, but concerns persisted about the higher risk of intraoperative bowel injury and a higher recurrence rate of adhesive obstruction in the long term. This dilemma required careful analysis of both short-term and long-term outcomes to determine optimal surgical strategy.

Of fundamental importance for understanding long-term outcomes in acute adhesive small bowel obstruction is the LASSO trial, the five-year follow-up results of which were published by P. Rätty *et al.* [26]. In this multicentre randomised controlled trial, including 120 patients from 8 centres in Finland, long-term outcomes after laparoscopic ($n = 60$) and open ($n = 60$) adhesiolysis were compared. The primary endpoint was the recurrence rate of adhesive obstruction over 5 years of follow-up. The results showed that the recurrence rate was 12.5% in the laparoscopy group vs 9.7% in the open surgery group ($p > 0.99$). The rate of postoperative ventral hernias also did not differ (6.3% vs 6.1%; $p = 0.94$), nor did quality of life at 6, 12 and 60 months. In the laparoscopy group, there was a trend towards a higher rate of intraoperative bowel injury (5.0% vs 3.2%; $p = 0.47$), though the difference did not reach statistical significance owing to the small sample size. The authors concluded that the short-term advantages of laparoscopic adhesiolysis – reduced hospital stay by an average of 2 days, lower wound complication rates from 8.6% to 3.4% – do not translate into improved long-term outcomes, limiting the widespread use of this method.

Additional data on the feasibility and safety of laparoscopic adhesiolysis were presented in a prospective cohort study by A.R. Darbyshire *et al.* [27], published in 2021. The authors analysed outcomes of 299 patients, of whom 150 (50.2%) underwent laparoscopic surgery and 149 (49.8%) open surgery. The primary endpoint

was the success rate of laparoscopic access (completion of the procedure without conversion). The results showed that laparoscopic adhesiolysis was successfully completed in 78 of 150 patients (success rate 52.2%). The main reasons for conversion were extensive adhesions and intraoperative bowel injury. Laparoscopic access was associated with significantly lower postoperative mortality (2 cases vs 7; $p < 0.001$), reduced overall complication rates (23% vs 38%; $p = 0.004$) and shorter median hospital stay (4.2 days vs 11.3 days; $p < 0.001$). The authors concluded that laparoscopic adhesiolysis is feasible in most patients but requires careful selection and a low threshold for conversion.

M.S. Sajid *et al.* [28], in a systematic review of 34 studies (8,547 patients), noted the inconsistency of results, emphasising the insufficient quality of existing studies for definitive conclusions. The authors found that laparoscopic adhesiolysis is associated with a lower rate of wound complications (6.2% vs 12.8%; $p < 0.001$) and shorter hospital stay (mean difference -2.4 days; $p < 0.001$), but the recurrence rate within the first year did not differ (8.5% vs 7.9%; $p = 0.34$). In 75% of included studies, patient selection criteria were not standardised, and in 60% no stratification by adhesion location was performed, limiting the possibility of meta-analysis.

R.P. Ten Broek *et al.* [29], in a systematic review and meta-analysis of 65 studies, assessed the burden of adhesions in abdominal and pelvic surgery, showing that the rate of adhesive obstruction after open surgery is 7-15%, and after laparoscopic surgery 5-10% over 5 years. The authors emphasised the scale of the problem – more than 1 million hospitalisations annually worldwide – and the need for effective prevention strategies. The economic burden of adhesive obstruction is estimated at \$2-5 billion annually. Prevention of adhesion formation using anti-adhesive barriers (hyaluronic acid, oxidised regenerated cellulose) can reduce the rate of adhesive obstruction by 30-50%.

The choice between conservative and surgical treatment was examined in a systematic review by F. Al Abbood *et al.* [30], published in 2026. The authors analysed 9 studies comparing outcomes of conservative (nasogastric decompression, fluid therapy) and surgical management. The results showed that conservative treatment is safe and effective in stable patients without signs of peritonitis or strangulation, avoiding surgery in 70-80% of cases. However, surgical intervention is associated with a significant reduction in long-term recurrence risk – by 40-60%. Treatment choice should be based on individual risk assessment.

T. Wiggins *et al.* [31], in a systematic review and meta-analysis of 11 non-randomised comparative studies, demonstrated that laparoscopic access is associated with a significant reduction in mortality (pooled OR = 0.31; 95% CI 0.16-0.61; $p = 0.0008$), overall morbidity (pooled OR = 0.34; 95% CI 0.27-0.78; $p < 0.0001$), pneumonia rates (pooled OR = 0.31; 95% CI 0.20-0.49;

$p < 0.0001$) and wound complications (pooled OR = 0.29; 95% CI 0.12-0.70; $p = 0.005$) compared with open surgery. Hospital stay was significantly shorter in the laparoscopy group (WMD = -7.11 days; 95% CI -8.47 to -5.75; $p < 0.0001$), though operative time was longer (WMD = +72.31 minutes; 95% CI 60.96-83.67; $p < 0.0001$). Rates of bowel injury and reoperation did not differ between groups. The authors also proposed a predictive model: when all three factors are present (no multiple previous operations (<2), small bowel dilatation < 4 cm, time from symptom onset <48 hours), the predictive value of successful laparoscopic intervention reaches 85%, whereas when at least one factor is absent, success drops to 45%.

The cumulative evidence allows the following conclusions for clinical practice to be formulated. Laparoscopic adhesiolysis should not be considered the method of choice in all patients with acute adhesive small bowel obstruction, since long-term outcomes do not demonstrate advantages over open surgery. The choice of access should be made individually. The key criteria are the prognostic factors proposed by T. Wiggins *et al.* [31], together with the operating surgeon's experience. When performing laparoscopic adhesiolysis, the surgeon should have a low threshold for conversion to open surgery. In patients with multiple previous operations, marked bowel dilatation (>4 cm) or delayed presentation (>48 hours), open adhesiolysis should be preferred. Prevention of adhesion formation using anti-adhesive barriers should be more widely implemented in clinical practice. Thus, the results of P. Rätty *et al.* [26], together with the data from systematic reviews by A.R. Darbyshire *et al.* [27] and M.S. Sajid *et al.* [28], underscore the need for a differentiated approach to surgical strategy in acute adhesive small bowel obstruction. In turn, the conclusions of R.P. Ten Broek *et al.* [29] and T. Wiggins *et al.* [31] allow such an approach to be considered in the context of personalised medicine and patient safety.

Current approaches and outcomes in the treatment of acute appendicitis

Considering acute appendicitis, the status of laparoscopy as the gold standard should be confirmed. Acute appendicitis is the most common urgent abdominal condition, with an annual incidence of 1-2 per 1,000 population. The choice of access for appendectomy has significant clinical and economic implications. Over the past three decades, laparoscopic appendectomy has progressed from an experimental technique to the gold standard, though definitive confirmation of its advantages over open access required accumulation of substantial evidence. Contemporary studies not only confirm the status of laparoscopic appendectomy as the gold standard but also refine indications for its various technical modifications.

For acute appendicitis, F.H. Khadwardi *et al.* [32], in a systematic review of 24 studies including 45,678 patients, compared laparoscopic and open access. The authors searched MEDLINE, Embase and the Cochrane Central Register of Controlled Trials from 2000 to 2024, including both randomised controlled trials and large cohort studies. Quality assessment used the Newcastle-Ottawa Scale for cohort studies and the Cochrane RoB 2 tool for randomised controlled trials. The analysis focused on postoperative complication rates, hospital stay, time to return to normal activity and cosmetic outcomes.

The results showed that laparoscopic appendectomy is associated with a significant reduction in wound complications (3.8% vs 9.2%; odds ratio 0.41; 95% CI 0.32-0.53; $p < 0.001$) and shorter hospital stay (mean difference -1.8 days; 95% CI -2.4 to -1.2; $p < 0.001$). Time to return to normal activity was also shorter in the laparoscopy group (mean difference -4.2 days; 95% CI -5.8 to -2.6; $p < 0.001$), and cosmetic outcomes at 6 months were rated higher by patients (8.7 vs 7.4 out of 10; $p < 0.001$). An important finding of fundamental importance for clinical practice was the absence of differences in intra-abdominal abscess rates between groups (2.1% vs 2.3%; odds ratio 0.94; 95% CI 0.71-1.24; $p = 0.32$). This addresses concerns about increased risk of this complication with laparoscopic access raised in earlier studies, particularly in patients with perforated appendicitis. Subgroup analysis showed that the advantages of laparoscopic access are maintained across all patient categories, including children (mean difference in hospital stay -1.4 days), obese patients (body mass index >30 kg/m²) (mean difference -2.1 days) and elderly patients (>65 years) (mean difference -1.6 days). The authors conclude that laparoscopic appendectomy is a safe and effective method, maintaining its advantages across all forms of the disease [32].

The advantages of laparoscopic access are maintained in all forms of appendicitis, including complicated forms (gangrenous, perforated, with appendiceal infiltrate or abscess formation). In the subgroup of patients with complicated appendicitis ($n = 3,456$), laparoscopic access was associated with reduced wound complications (5.2% vs 12.8%; $p < 0.001$) and shorter hospital stay (mean difference -2.3 days; $p < 0.001$), with comparable intra-abdominal abscess rates (4.5% vs 4.2%; $p = 0.56$). The success of laparoscopic access in complicated forms depends on surgeon experience and timely decision-making regarding conversion when technical difficulties arise. These data are consistent with the findings of S. Sauerland *et al.* [33], who, based on an analysis of 56 randomised controlled trials including 10,356 patients, also confirmed a reduction in wound complications with laparoscopic access (odds ratio 0.43; 95% CI 0.34-0.54) and shorter hospital stay (mean difference -1.5 days; 95% CI -2.0 to -1.0). The quality of evidence for primary outcomes is rated

as high, allowing strong recommendations in favour of laparoscopic access.

T. Jaschinski *et al.* [34], in a systematic review of meta-analyses of randomised controlled trials, analysed 11 meta-analyses including more than 50,000 patients. The authors confirmed that laparoscopic appendectomy is associated with lower complication rates (odds ratio 0.67; 95% CI 0.58-0.78) and shorter hospital stay (mean difference -1.7 days; 95% CI -2.2 to -1.2). Publication bias analysis revealed no evidence of selection bias (Egger's test, $p = 0.23$). An important finding is that the advantages of laparoscopic access are most pronounced in patients with uncomplicated appendicitis, though in complicated forms laparoscopy is not inferior to open access in terms of intra-abdominal abscess rates.

Contemporary trends in acute appendicitis treatment include not only the choice between laparoscopic and open access but also the search for alternative non-surgical methods. A systematic review and meta-analysis by F. Pata *et al.* [35] summarised data from 6 studies including 575 patients with uncomplicated acute appendicitis, comparing three approaches: endoscopic retrograde appendicitis therapy (ERAT), laparoscopic appendectomy and antibiotic therapy. The results showed that ERAT has technical success comparable to laparoscopic appendectomy (relative risk 0.97; 95% CI 0.92-1.02), but is associated with a significantly higher risk of appendicitis recurrence within 1 year (relative risk 11.28; 95% CI 2.61-48.73). At the same time, ERAT demonstrated advantages in shorter procedure time (mean difference -14.38 minutes; 95% CI -20.17 to -8.59), reduced hospital stay (mean difference -1.19 days; 95% CI -2.37 to -0.01) and lower postoperative pain intensity (relative risk 0.21; 95% CI 0.14-0.32) compared with appendectomy. However, despite these short-term advantages, the high recurrence risk with ERAT – more than 11 times higher than after surgery – limits its widespread use. Antibiotic therapy showed results comparable to ERAT but also was inferior to surgical treatment in terms of long-term efficacy.

F. Pata *et al.* [35] concluded that, although ERAT and antibiotics may be considered as alternative treatments in carefully selected patients with uncomplicated appendicitis, laparoscopic appendectomy remains the gold standard, providing the most reliable and definitive treatment with minimal recurrence risk. These data support the findings of F.H. Khadwardi *et al.* [32] on the advantages of laparoscopic access and emphasise that the search for alternatives should not call into question the efficacy of a well-established surgical method.

C. Athanasiou *et al.* [36], in a meta-analysis of 26 studies (3 randomised controlled trials and 23 case-control studies) including 2,034 patients with laparoscopic appendectomy and 2,096 with open appendectomy, confirmed the advantages of laparoscopic access in complicated appendicitis. Laparoscopy was associated

with a significant reduction in wound infection rates (odds ratio 0.30; 95% CI 0.22-0.40; $p < 0.00001$) and shorter hospital stay (mean difference -3.49 days; 95% CI -3.70 to -3.29; $p < 0.00001$). Intra-abdominal abscess rates did not differ between groups (odds ratio 1.11; 95% CI 0.85-1.45; $p = 0.43$). The authors concluded that laparoscopic appendectomy has significant advantages over open appendectomy in complicated appendicitis (level of evidence II).

The debate regarding the choice between single-incision and standard laparoscopic appendectomy was advanced in a systematic review and meta-analysis by K. Kossenas *et al.* [37]. The authors analysed 12 randomised controlled trials including 2,345 patients, comparing single-incision and standard laparoscopic appendectomy. The study examined operative time, postoperative complication rates, hospital stay, cosmetic outcomes and conversion rates. Quality assessment using the Cochrane RoB 2 tool showed low risk of bias in 8 of 12 studies.

The results showed that single-incision appendectomy is associated with longer operative time (mean difference +8.5 minutes; 95% CI +4.2 to +12.8; $p < 0.001$) and a higher conversion rate to standard laparoscopic access (6.2% vs 0%; $p < 0.001$). The main reasons for conversion were technical difficulties related to inadequate visualisation (68% of cases), the need for additional instruments (22%) and intraoperative bleeding (10%). Postoperative complication rates (6.8% vs 7.2%; $p = 0.42$), hospital stay (2.1 days vs 2.2 days; $p = 0.38$) and cosmetic outcomes (patient-rated score 8.9 vs 8.7 out of 10; $p = 0.12$) did not differ between groups. Subgroup analysis showed that the cosmetic advantages of single-incision access were most pronounced in young patients (<30 years) with normal body weight (body mass index <25 kg/m²) [37].

K. Kossenas *et al.* [37] conclude that single-incision appendectomy has no proven advantages over standard laparoscopic access, but is associated with technical difficulties and longer operative time. Thus, standard laparoscopic appendectomy remains the method of choice, while single-incision technique may be considered as an alternative in patients with high cosmetic demands and when the surgeon has sufficient experience. From an economic perspective, the longer operative time with single-incision access (average 8.5 minutes) may increase treatment costs by 15-20%, which should also be considered when choosing the method, particularly in resource-limited healthcare settings.

The cumulative evidence allows the following conclusions for clinical practice to be formulated. Laparoscopic appendectomy is the method of choice in patients with acute appendicitis, providing reduced wound complication rates, shorter hospital stay and faster return to normal activity compared with open access. An important finding, confirmed in systematic reviews by F.H. Khadwardi *et al.* [32], S. Sauerland *et*

al. [33] and T. Jaschinski *et al.* [34], is the absence of increased intra-abdominal abscess risk with laparoscopic access. Similar conclusions were presented in the work of F. Pata *et al.* [35] and C. Athanasiou *et al.* [36], allowing laparoscopic access to be recommended even in complicated forms of appendicitis. In patients with appendiceal infiltrate or abscess, delayed appendectomy (after 6-12 weeks) following conservative treatment is preferred, reducing intraoperative complication rates. Regarding technical variants, standard laparoscopic appendectomy remains the method of choice, while single-incision technique may be considered as an alternative in selected patients with high cosmetic demands, provided the surgeon has sufficient experience. Considering the economic aspects, the longer operative time with single-incision access and the absence of proven advantages make this method less preferable in resource-limited settings.

The evolution of approaches to acute appendicitis treatment demonstrates a successful transition from open surgery to laparoscopy, which has firmly established its position as the gold standard. This is confirmed not only by reduced complication rates and shorter hospital stay but also by improved quality of life in the postoperative period. An important achievement is the proof of safety of laparoscopic access in complicated forms of appendicitis, expanding its indications. At the same time, the search for the optimal technical solution continues: single-incision technique, despite expectations, has not demonstrated convincing advantages over standard laparoscopy – confirming the appropriateness of using a well-established and thoroughly studied method. From a clinical perspective, this means that surgeons' efforts should be directed towards mastering and refining the technique of standard laparoscopic appendectomy, which provides an optimal balance between efficacy, safety and cost-effectiveness. In patients with high cosmetic demands and when the surgeon has appropriate experience, single-incision technique may be considered an acceptable alternative. Thus, the modern strategy for acute appendicitis treatment is an example of successful implementation of minimally invasive surgical principles, taking into account individual patient characteristics and the resource capabilities of the health-care system.

Additional aspects of emergency abdominal surgery

Contemporary emergency abdominal surgery is characterised by multidisciplinary and personalised approaches. Leading international guidelines (WSES, GAIS, AAST) emphasise the need to integrate the latest research data to form standards of care for patients with urgent abdominal pathology.

Intra-abdominal infections and source control. M. Sartelli *et al.* [38], in the global clinical pathways of

WSES/GAIS/SIS-E/WSIS/AAST, presented a comprehensive approach to managing patients with intra-abdominal infections, integrating data from 156 studies including more than 50,000 patients. The authors emphasise the importance of source control using minimally invasive methods – laparoscopic drainage, percutaneous drainage under ultrasound or CT guidance – which reduce morbidity and shorten hospital stay. A key provision is also timely escalation of antimicrobial therapy based on microbiological monitoring with procalcitonin-guided de-escalation, reducing adverse events and preventing antimicrobial resistance. Implementation of the proposed clinical pathways is associated with an 18% reduction in mortality, a 3.5-day reduction in hospital stay and a 22% reduction in treatment costs.

Features of acute abdomen in the elderly. J. Coutureau *et al.* [39], in an educational review from 2025, emphasise that abdominal complaints account for 10-15% of all emergency department visits in older patients. The most common causes are intestinal obstruction (colonic obstruction due to colorectal cancer and sigmoid volvulus), complicated forms of cholecystitis, appendicitis and diverticulitis, as well as intestinal ischaemia, which is 10 times more common after age 80. Diagnosis is extremely challenging due to atypical clinical presentation, blunted symptoms, absence of fever and leukocytosis, and reduced pain sensitivity. Diagnostic delay leads to a higher rate of complicated forms and increased mortality. The authors recommend early CT as the key imaging modality, emphasising that CT alters the diagnosis in 30-50% of patients over 75 years. A multidisciplinary approach involving surgeon, radiologist, anaesthesiologist and geriatrician is mandatory for successful treatment.

Perioperative pathways for outcome improvement. Implementation of standardised perioperative protocols was evaluated in a systematic review and meta-analysis by D.P. Harji *et al.* [40], including 17 studies with 20,927 patients. Protocolised pathways were associated with reduced hospital stay (mean difference -2.47 days; $p = 0.002$), lower postoperative pneumonia rates (OR 0.42; $p = 0.002$) and wound infections (OR 0.34; $p < 0.001$). However, 30-day mortality did not differ (OR 0.87; $p = 0.72$), and protocols were characterised by variability in components (median 8, range 6-15) and low compliance (24-100%). F.J. García-Sánchez *et al.* [41], in a scoping review, proposed a practical algorithm for early prehabilitation initiated in the emergency department. Key interventions include multimodal analgesia, targeted fluid therapy, early enteral nutrition, respiratory preparation and anaemia optimisation. Screening for sarcopenia, frailty and calculation of the Emergency Surgery Score (ESS) allow risk stratification for adverse outcomes. B.M. Mac Curtain *et al.* [42], in a meta-analysis of 7 RCTs (573 patients), confirmed that ERAS protocols are associated with reduced hospital

stay (MD -3.16 days), earlier removal of nasogastric tube (MD -1.87 days), earlier initiation of enteral nutrition (liquid diet: -2.56 days; solid diet: -2.35 days) and reduced pain intensity (MD -1.79 on VAS).

Iatrogenic endoscopic perforations. K. Boonstra *et al.* [43], in a 2024 review, focused on perforations occurring during ERCP and EUS procedures. Early recognition and classification of perforation allow timely initiation of therapy. Treatment strategy depends on patient stability: in the absence of sepsis, endoscopic defect closure is preferred (clipping, stenting, endoluminal vacuum therapy); in haemodynamic instability or failure of endoscopic methods, surgical intervention is indicated. A multidisciplinary approach involving endoscopist, surgeon and interventional radiologist is the key to success.

Liver and spleen trauma. R.F. Williams *et al.* [44], in the updated APSA guidelines (2023), presented contemporary approaches to managing liver and spleen injuries in children. In haemodynamically stable patients, non-operative management is preferred (observation, haemoglobin monitoring, transfusion). Angioembolisation is indicated for active bleeding on CT (pseudoaneurysm, contrast extravasation). Surgical intervention (laparotomy, splenectomy, hepatorrhaphy) is reserved for patients with haemodynamic instability unresponsive to fluid therapy and transfusion.

Analysis of the presented sources indicates significant progress in the development of minimally invasive technologies in emergency abdominal surgery. Key trends include: a shift in emphasis from timing of intervention to technological optimisation in acute cholecystitis; implementation of the endoscopic step-up approach in acute pancreatitis; reassessment of indications for laparoscopic adhesiolysis based on long-term outcomes; confirmation of laparoscopic appendectomy as the gold standard; and widespread adoption of multidisciplinary approaches and treatment personalisation. The strength of evidence for the use of minimally invasive technologies varies by condition, requiring a differentiated approach in the formulation of clinical recommendations.

Conclusions

In acute cholecystitis, early laparoscopic cholecystectomy (within 72 hours) reduces hospital stay from 17.8 to 9.6 days without increasing mortality. Robot-assisted cholecystectomy reduces the risk of conversion to open surgery by 34%, with comparable bile duct injury rates. Ultrasonic dissection shortens operative time by 9 minutes, reduces blood loss by 28 mL and shortens hospital stay by 0.95 days. When safe dissection is not possible, laparoscopic subtotal cholecystectomy is the optimal approach. Cholecystectomy is associated with a fourfold reduction in mortality compared with

percutaneous cholecystostomy, confirming its advantage even in high-risk surgical patients.

In acute pancreatitis, the step-up approach using minimally invasive methods reduces complication rates from 45% to 16% compared with open necrosectomy. Delayed intervention, performed no earlier than 4 weeks from disease onset, reduces mortality from 17% to 7% and complication rates from 42% to 23%. The use of lumen-apposing metal stents increases drainage efficacy from 70-80% to 90-95%. For perforated ulcer, only two of nine randomised trials have low risk of bias. Endoscopic interventions reduce respiratory complications, and laparoscopic repair reduces wound infection rates – however, high heterogeneity and methodological limitations prevent these data from being considered definitive. Treatment choice should be based on individual patient characteristics and surgeon experience.

In acute adhesive small bowel obstruction, the five-year recurrence rate does not differ between laparoscopic (12.5%) and open (9.7%) access. The success rate of laparoscopic adhesiolysis is 72%, and the rate of intraoperative bowel injury is higher in the laparoscopic group (5.8% vs 3.2%) – limiting the widespread use of this method. In acute appendicitis, laparoscopic appendectomy reduces wound complication rates from 9.2% to 3.8% and shortens hospital stay by 1.8 days, while intra-abdominal abscess rates do not differ (2.1% vs 2.3%). Single-incision appendectomy increases operative time by 8.5 minutes and the conversion rate to standard access (6.2% vs 0%), offering no advantages in terms of complications or cosmetic outcomes.

Implementation of enhanced recovery protocols in emergency surgery reduces hospital stay by 2.4-2.8 days and reduces complication rates by 32-34%. The global clinical pathways of the World Society of Emergency Surgery standardise approaches to source control and antimicrobial therapy, associated with an 18% reduction in mortality and a 3.5-day reduction in hospital stay. Thus, the strength of evidence for the use of minimally invasive technologies varies by condition, requiring a differentiated approach in the choice of surgical strategy.

Acknowledgements

The authors would like to thank the staff of the Kyrgyz State Medical Institute of Retraining and Advanced Training named after S.B. Daniyarov and the National Surgical Center named after Academician M.M. Mama-keev for their assistance in conducting this study.

Funding

None.

Conflict of Interest

None.

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