CZARNOTA, Maksymilian, ADAMOWICZ, Martyna and GÓRNIAK, Aleksandra. Minimally Invasive Surgery in Modern Medicine: A Review of Laparoscopic Techniques, Indications, and Postoperative Outcomes. Journal of Education, Health and Sport. 2025;83:61761. eISSN 2391-8306.
https://doi.org/10.12775/JEHS.2025.83.61761
https://apcz.umk.pl/JEHS/article/view/61761

The journal has had 40 points in Minister of Science and Higher Education of Poland parametric evaluation. Annex to the announcement of the Minister of Education and Science of 05.01.2024 No. 32318. Has a Journal's Unique Identifier: 201159. Scientific disciplines assigned: Physical culture sciences (Field of medical and health sciences); Health Sciences (Field of medical and health sciences).
Punkty Ministerialne 40 punktów. Załącznik do komunikatu Ministra Nauki i Szkolnictwa Wyższego z dnia 05.01.2024 Lp. 32318. Posiada Unikatowy Identyfikator Czasopisma: 201159. Przypisane dyscypliny naukowe: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).
The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 31.05.2025. Revised: 30.06.2025. Accepted: 04.07.2025. Published: 06.07.2025.

Minimally Invasive Surgery in Modern Medicine: A Review of Laparoscopic Techniques, Indications, and Postoperative Outcomes

Maksymilian Czarnota
https://orcid.org/0009-0002-9322-4494
bonamaks@gmail.com
Polish Red Cross Maritime Hospital in Gdynia, 1 Powstania Styczniowego Street, 81-519 Gdynia, Poland

Martyna Adamowicz
https://orcid.org/0009-0000-0818-6864
m.adamowicz@gumed.edu.pl
University Clinical Centre in Gdańsk, 7 Dębinki Street, 80-952 Gdańsk, Poland

Aleksandra Górniak
https://orcid.org/0009-0003-5211-9468
olagorniak99@gmail.com
Copernicus Healthcare Entity Ltd., Mikołaj Kopernik Hospital, 1–6 Nowe Ogrody Street, 80-803 Gdańsk, Poland

Abstract

Background: Minimally invasive surgery has reshaped operative care, yet contemporary evidence is fragmented across specialties.
Objective: To integrate recent data on laparoscopic indications, technological advances and patient-centred outcomes.
Methods: Narrative review of 37 PubMed-indexed studies (2022–2025) encompassing randomised trials, cohort studies and meta-analyses in general, hepatobiliary, bariatric, gynaecologic and urologic surgery. Extracted variables included operative time, blood loss, complications, length of stay, quality-of-life and long-term results.
Results: Relative to open surgery, laparoscopy reduced blood loss by 30–60 %, wound infections by up to 70 % and hospital stay by 1–3 days without prolonging operative time. Oncologic clearance and five-year survival were preserved in colorectal, gastric and cervical cancers. Enhanced visualisation, single-incision access and staple-line optimisation improved technical efficiency, while restrictive fluid and ERAS pathways halved pulmonary complications and hastened recovery. Elderly and frail patients experienced lower pulmonary morbidity and faster functional return, while paediatric and fertility-preserving gynaecologic procedures maintained safety and sustained quality of life.
Conclusions: Laparoscopic techniques should be preferred whenever technically feasible, including complex, emergency and high-risk scenarios, provided adequate expertise and structured peri-operative care. Priority research areas include harmonised outcome definitions, registries with ≥ 10-year follow-up, robust cost-utility analyses and trials in under-represented populations to consolidate the value and equity of modern minimally invasive surgery.

Keywords: Minimally invasive surgery; Laparoscopic techniques; Surgical outcomes; Enhanced recovery after surgery; Single-incision laparoscopy; Postoperative complications; Colorectal surgery; Bariatric procedures; Gynaecologic laparoscopy; Patient-reported outcomes;

1. Introduction

Minimally invasive surgery has redefined peri-operative care by limiting access trauma, shortening recovery time and enhancing patient satisfaction [1]. Early evidence derived from structured patient-education programmes demonstrates that the benefits of laparoscopy can be further amplified when patients receive tailored coaching that optimises mobilisation, analgesia use and self-management after discharge [1].

Within general surgery, laparoscopic cholecystectomy is now considered the gold standard for gallbladder disease, including complicated acute cholecystitis [2]. Parallel progress in colorectal practice has seen laparoscopic resection adopted for malignant large-bowel obstruction after self-expandable metallic stent placement, providing equivalent oncological

control with reduced short-term morbidity [3]. Enhanced peri-operative protocols, such as goal-directed fluid restriction during laparoscopic gastrectomy, highlight the continual refinement of technique-specific anaesthetic management aimed at minimising postoperative complications [4].

High-quality meta-analyses comparing laparoscopic and open approaches confirm consistent reductions in wound infection, postoperative pain and length of hospital stay after minimally invasive cholecystectomy across diverse patient cohorts [5]. Importantly, favourable outcomes extend beyond the immediate postoperative phase: patients who undergo primary laparoscopic colon resection exhibit improved survival and reduced intra-abdominal adhesion formation when subsequently subjected to cytoreductive surgery and hyperthermic intraperitoneal chemotherapy for metachronous peritoneal metastasis [6].

Technical evolution has expanded the remit of laparoscopy to complex metabolic surgery. Randomised studies evaluating staple-line reinforcement strategies during laparoscopic sleeve gastrectomy demonstrate that meticulous intra-operative modification can curb early haemorrhagic and leak-related complications without compromising weight-loss efficacy [7]. Even high-risk surgical candidates benefit; a propensity-matched analysis of frail patients undergoing emergency hernia repair revealed lower pulmonary complication rates and shorter intensive-care stays after a minimally invasive approach [8].

Outside general surgery, laparoscopy has matured into an oncologically sound alternative in early-stage cervical cancer, offering comparable disease-free survival while decreasing peri-operative blood loss [9]. Likewise, single-port distal gastrectomy performed for malignancy achieves three-year quality-of-life scores that parallel—or surpass—those reported after conventional multi-port procedures, underscoring the contribution of incision minimisation to long-term patient-centred outcomes [10].

Beyond routine cases, laparoscopy has proven adaptable in highly complex scenarios. Narrative evidence synthesising more than 600 technically demanding cholecystectomies underscores the value of objective difficulty grading and “bail-out” strategies—subtotal resection and fundus-first dissection—to avert bile-duct injury without converting to open surgery [11]. Likewise, a prospective comparative study indicates that synchronous laparoscopic colorectal and hepatic resections for stage-IV disease achieve R0 rates and five-year survival comparable with staged or open approaches while halving overall morbidity

[12]. Randomised data in elderly patients show that a transabdominal pre-peritoneal repair for inguinal hernia reduces postoperative pain by 35 % relative to open mesh repair and shortens convalescence by two days [13]. Importantly, patient-reported outcome measures collected after laparoscopic appendectomy confirm rapid restoration of baseline physical function and health-related quality of life within the first postoperative fortnight [14].

Metabolic surgery illustrates how laparoscopy continues to evolve. A systematic review that pooled adolescent and adult cohorts demonstrated equivalent excess-weight loss after sleeve gastrectomy irrespective of age, consolidating the technique's role across the life-course [15]. Comparable durability has been documented in abdominal-wall reconstruction: a multicentre randomised trial found no inferiority in recurrence rates at three years after laparoscopic versus open repair of large incisional hernias, despite significant reductions in wound complications and length of stay in the minimally invasive arm [16].

Technical refinements extend to single-incision surgery. Meta-analysis of randomised trials in acute appendicitis shows that single-incision laparoscopic appendectomy maintains operative safety while improving cosmesis and patient satisfaction [17]. In metabolic surgery, comparative synthesis of Roux-en-Y gastric bypass and sleeve gastrectomy confirms superior type-2-diabetes remission after the bypass, whereas weight-loss trajectories converge by 24 months [18]. For bilateral inguinal hernia repair, a randomised study favours the totally extraperitoneal approach over transabdominal pre-peritoneal repair in reducing early postoperative pain without compromising recurrence risk [19]; complementary institutional data corroborate equivalent safety for single-incision versus conventional three-port appendectomy in adults [20].

The breadth of laparoscopic application now encompasses anti-reflux surgery [21] and refined mesh-fixation strategies that meta-analysis shows are unnecessary in routine transabdominal pre-peritoneal repair, thereby eliminating a cost driver without affecting outcomes [22]. Timing also matters: a randomised trial in acute appendicitis demonstrated that delaying laparoscopic appendectomy up to 24 hours does not increase perforation or abscess formation, enabling resource optimisation in busy emergency theatres [23]. Long-term assessments reveal that health-related quality of life after bariatric surgery remains stable for up to five years, provided early multidisciplinary follow-up is maintained [24].

Gynaecological laparoscopy mirrors these advancements. Meta-analysis of more than 4 500 myomectomies shows that laparoscopic access halves transfusion rates and shortens hospital stay versus laparotomy, with no detriment to fertility outcomes [25]. Technical series confirm that donor nephrectomy, hysterectomy and myomectomy can be safely performed in day-surgery pathways or under enhanced-recovery protocols, maintaining patient satisfaction and controlling costs [26–30]. Comparative cohort data suggest that three-dimensional visualisation improves knot-tying efficiency during benign hysterectomy, translating into shorter total operative time [32], while robotic assistance offers incremental precision for complex myomectomy but at the expense of longer docking times and higher capital costs [33].

Special populations also benefit. In paediatric biliary disease, a one-step strategy combining endoscopic retrograde cholangiopancreatography with laparoscopic cholecystectomy reduces total anaesthetic exposure and length of hospitalisation compared with staged management [34]. Registry-level data confirm that early adoption of laparoscopy in acute cholecystitis does not compromise safety metrics even during off-hour presentations [35], and parallel analyses in appendicitis reiterate lower wound-infection rates than open surgery despite broader inclusion of elderly and septic patients [36]. Furthermore, laparoscopic liver resection after previous gastrectomy does not increase bile-leak risk provided meticulous adhesiolysis and parenchymal transection under low central-venous pressure are observed [37].

Collectively, these studies illustrate the breadth, maturity and continual innovation of laparoscopic surgery across multiple specialties, patient demographics and complexity strata. However, heterogeneity in study design, outcome definitions and follow-up length hampers direct comparison and obscures the true magnitude of benefit in certain subgroups. Accordingly, the present review synthesises evidence from 37 peer-reviewed investigations published between 2022 and 2025 to (i) characterise current indications for laparoscopy across visceral, bariatric, gynaecologic, urologic and hepatobiliary surgery; (ii) appraise operative techniques and technological adjuncts; and (iii) delineate short- and long-term patient-centred outcomes. By integrating high-quality randomised trials, prospective cohorts and up-to-date systematic reviews, we aim to provide clinicians, educators and policy-makers with a comprehensive reference that informs practice and identifies priorities for future research in the era of minimally invasive surgery.

2. Methodology

This review was conducted according to established methodological standards for narrative medical reviews, with a structured approach to literature selection, analysis, and synthesis. The goal was to provide a comprehensive and evidence-based summary of current laparoscopic techniques, clinical indications, and postoperative outcomes across surgical disciplines.

Data Sources and Search Strategy

This review is based exclusively on 37 scientific articles identified and selected by the authors from the PubMed database between 2022 and 2025. The selection process prioritised randomized controlled trials, prospective and retrospective cohort studies, systematic reviews, and meta-analyses published in peer-reviewed journals. Only articles written in English and focusing on laparoscopic surgery in adult or paediatric populations were included.

No automated search algorithm was applied; instead, manual selection was performed to ensure thematic relevance and scientific integrity. Each article was screened based on title, abstract, and—when necessary—full-text content, with particular attention paid to:

1. Clinical indications for laparoscopic surgery,
2. Description or comparison of laparoscopic techniques,
3. Evaluation of postoperative outcomes (e.g., complications, quality of life, hospital stay),
4. Inclusion of laparoscopic intervention as the primary or comparative surgical modality.

Articles focusing exclusively on robotic, open, or endoscopic procedures without a laparoscopic comparator arm were excluded. Likewise, expert opinions, letters to the editor, and case reports were omitted to preserve methodological rigour.

Inclusion Criteria

Articles were included if they met the following criteria:

- Published between 2022 and 2025;
- Indexed in PubMed;

- Focused on laparoscopic surgery in any of the following fields: general surgery, gastrointestinal surgery, gynaecology, urology, bariatric/metabolic surgery, or hepatobiliary surgery;
- Reported outcomes related to surgical technique, perioperative management, postoperative recovery, long-term follow-up, or patient-reported outcomes;
- Employed a scientifically valid methodology (randomised trial, cohort study, or systematic review/meta-analysis).

Data Extraction and Synthesis

All 37 articles were reviewed in full by the authors and assigned to thematic domains based on the surgical specialty and focus of the study. Key data were extracted, including study design, population characteristics, type of laparoscopic intervention, comparator (if applicable), perioperative parameters, postoperative outcomes, and long-term results.

The synthesis was performed narratively, with comparative analysis where appropriate. Where multiple studies addressed similar interventions or outcomes, findings were integrated to identify consistent patterns, benefits, and limitations of laparoscopic approaches.

No quantitative meta-analysis was conducted, as the included studies varied significantly in terms of patient populations, surgical procedures, outcome definitions, and follow-up durations.

Ethical Considerations

As this work is a narrative review based solely on published literature, institutional review board (IRB) approval and informed consent were not required.

3. Indications for Laparoscopic Surgery Across Specialties

3.1 Gastrointestinal Surgery

Appendix and Small Bowel – Laparoscopy has become the preferred approach for uncomplicated and complicated appendicitis across age ranges. Prospective and randomised evidence shows faster convalescence, lower wound-infection rates, and comparable perforation or abscess risk whether the operation is undertaken immediately or delayed up to 24 h after admission [14, 17, 20, 23, 36]. Single-incision techniques provide equivalent safety

with superior cosmetic satisfaction [17, 20], supporting their routine adoption in motivated adults.

Gallbladder and Biliary Tract – For symptomatic cholelithiasis and acute cholecystitis, subtotal and total laparoscopic cholecystectomy remain the gold standard. Systematic synthesis confirms fewer surgical-site infections, shorter hospital stay, and lower overall morbidity than open cholecystectomy, even in complicated disease [2, 5, 11, 35]. In paediatric cohorts, a one-step strategy combining endoscopic retrograde cholangiopancreatography with laparoscopic cholecystectomy safely reduces total anaesthetic exposure and length of stay [34].

Colorectal Disease – In malignant large-bowel obstruction bridged with self-expandable metallic stents, laparoscopic resection achieves equivalent oncological clearance while halving early morbidity versus open surgery [3]. Long-term follow-up indicates that a prior laparoscopic colon resection does not compromise, and may even facilitate, subsequent cytoreductive surgery with hyperthermic intraperitoneal chemotherapy for metachronous peritoneal metastasis [6]. Concomitant laparoscopic colectomy and hepatectomy for synchronous colorectal liver metastases are likewise feasible, offering R0 rates and survival comparable with staged or open strategies while limiting cumulative complications [12].

Stomach and Bariatric Procedures – Laparoscopic distal or total gastrectomy for cancer benefits from enhanced-recovery anaesthetic protocols; restrictive goal-directed fluid management reduces pulmonary complications without increasing renal events [4]. Single-port distal gastrectomy yields comparable three-year disease-specific and quality-of-life outcomes to the conventional multi-port technique while further diminishing wound pain [10]. In metabolic surgery, sleeve gastrectomy and Roux-en-Y gastric bypass performed laparoscopically provide durable weight loss and remission of type-2 diabetes; comparative meta-analysis shows superior glycaemic control after bypass, whereas long-term weight trajectories converge by two years [7, 15, 18, 24].

3.2 Hepatobiliary and Urologic Surgery

Laparoscopic liver resection is now routinely extended to patients with extensive upper-abdominal adhesions; prior gastrectomy does not increase bile-leak risk when meticulous adhesiolysis is combined with low central-venous-pressure transection techniques [37]. Early adoption of a totally laparoscopic approach for primary colon cancer is also advantageous

when patients later require cytoreductive liver surgery [6]. Living-donor nephrectomy is safely accomplished laparoscopically, with low conversion rates and rapid functional recovery; institutional data confirm reproducible outcomes across transperitoneal, retroperitoneal, and hand-assisted variants, with incremental cost differences driven mainly by disposables [26, 29].

3.3 Gynaecologic Surgery

Minimally invasive hysterectomy—whether multi-port, single-port, three-dimensional, or day-surgery protocol—reduces blood loss, analgesic requirements, and convalescence compared with open abdominal hysterectomy, without compromising oncological adequacy in benign or premalignant disease [27, 30, 32]. Laparoscopic myomectomy halves transfusion risk and hospital stay relative to laparotomy while preserving fertility; prospective and meta-analytic evidence confirms favourable pregnancy rates and obstetric outcomes [25, 28, 31, 33]. In early-stage cervical cancer, laparoscopic radical hysterectomy provides survival and recurrence outcomes equivalent to the open procedure, with less intra-operative haemorrhage and faster mobilisation [9].

3.4 Abdominal Wall and Hernia Surgery

Randomised trials in elderly and frail populations support transabdominal pre-peritoneal or totally extraperitoneal laparoscopic repair of inguinal hernia as they offer 30–40 % reductions in postoperative pain scores and earlier return to activity compared with open mesh repair [8, 13, 19]. Systematic analysis demonstrates no added benefit from routine mesh fixation in transabdominal pre-peritoneal repair, allowing omission of tacks or sutures without increasing recurrence [22]. For large incisional hernias, a multicentre randomised trial confirms that laparoscopic repair achieves recurrence rates comparable with open underlay techniques while substantially diminishing wound complications and length of stay [16].

3.5 Oesophageal and Anti-Reflux Surgery

Laparoscopic Nissen fundoplication remains the benchmark procedure for medication-refractory gastro-oesophageal reflux disease, achieving durable symptom control and low dysphagia rates with minimal morbidity [21].

4. Laparoscopic Techniques and Technological Innovations

4.1 Access Strategies: Multi-Port, Reduced-Port and Single-Incision

Conventional four- or five-port laparoscopy remains the benchmark for most visceral procedures, yet progressive port reduction aims to minimise parietal trauma without compromising dexterity. A randomised trial in distal gastrectomy showed that a single-port approach reproduced oncological adequacy and three-year quality-of-life scores of the multi-port standard while lowering early postoperative pain and improving cosmetic satisfaction [10]. Meta-analysis of randomised appendectomy trials corroborates these findings, demonstrating non-inferior operative time and complication rates for single-incision access, with superior body-image perception and scar satisfaction [17]. Institutional data in adult acute appendicitis further confirm equivalent safety profiles between single-incision and conventional three-port techniques, facilitating broader implementation outside high-volume centres [20].

4.2 Enhanced Visualisation and Instrumentation

High-definition three-dimensional (3-D) optics have been proposed to mitigate the depth-perception limitations of standard two-dimensional systems. A randomised clinical trial in benign hysterectomy revealed that 3-D laparoscopy shortened total operative time by improving intracorporeal knot-tying efficiency without increasing equipment costs or complication rates [32]. At the other end of the technology spectrum, systematic synthesis of robotic-assisted versus pure laparoscopic myomectomy showed that robotic articulation offered incremental precision and lower conversion rates in uteri >500 g, yet at the expense of longer docking times and higher direct costs [33]. These data suggest that image-guided depth perception may yield a more favourable cost-benefit ratio than full robotic platforms for many benign indications.

4.3 Staple-Line Optimisation and Energy Devices

In bariatric surgery, a prospective randomised study comparing omentopexy with staple-line clipping during sleeve gastrectomy demonstrated a 48 % relative reduction in early haemorrhagic events with omentopexy and no difference in leak rate, indicating that adjunct

tissue reinforcement may counteract mechanically induced bleeding without prolonging operative time [7]. Comparative meta-analysis of Roux-en-Y gastric bypass versus sleeve gastrectomy likewise underscores the centrality of staple-line integrity, with leak rates consistently <2 % across both procedures when modern energy sealing devices are used [18].

4.4 Anaesthetic and Peri-operative Protocols

Goal-directed restrictive fluid therapy during laparoscopic gastrectomy reduced pulmonary complications by 35 % compared with a liberal strategy while preserving renal function, underscoring the need for procedure-specific haemodynamic targets in pneumoperitoneum [4]. Enhanced-recovery-after-surgery (ERAS) pathways in laparoscopic hysterectomy shortened postoperative length of stay by almost 24 h without increasing readmissions, driven mainly by early mobilisation and opioid-sparing multimodal analgesia [27]. Complementary evidence from a systematic review of structured patient-education programmes demonstrates that tailored peri-operative coaching further accelerates discharge readiness and decreases unscheduled consultations [1].

4.5 Mesh Fixation, Sutureless Repair and Cost Containment

A meta-analysis of randomised trials in transabdominal pre-peritoneal inguinal hernia repair found no reduction in recurrence when permanent fixation devices were used, suggesting that routine tack or suture placement is unnecessary in most primary repairs [22]. Randomised data in bilateral inguinal hernia repair additionally indicate that a totally extraperitoneal approach yields lower postoperative pain scores and earlier return to work than transabdominal repair while obviating mesh fixation altogether [19]. These findings have direct cost implications, as omission of fixation devices and shorter convalescence translate into measurable savings for healthcare systems and patients.

4.6 Combined and Hybrid Procedures

Technical feasibility has extended laparoscopy beyond single-organ surgery. Simultaneous laparoscopic colorectal and hepatic resections for synchronous stage-IV disease achieve R0 margins and five-year survival equivalent to staged open surgery while halving aggregate morbidity [12]. Prior laparoscopic colon resection also facilitates subsequent cytoreductive surgery with hyperthermic intraperitoneal chemotherapy by reducing adhesion burden and operative blood loss [6]. In paediatric biliary disease, a one-step protocol combining

endoscopic retrograde cholangiopancreatography with laparoscopic cholecystectomy reduces total anaesthetic exposure and shortens hospitalisation without added complications compared with staged management [34].

5. Peri-operative Outcomes and Patient Safety

5.1 Operative Time, Blood Loss, and Intra-operative Complications

Across digestive, bariatric, and gynaecologic surgery, randomised and prospective evidence demonstrates that laparoscopic access consistently limits intra-operative blood loss compared with open surgery while maintaining comparable or shorter operative times in most settings [3, 7, 9, 16, 25]. Meta-analyses of cholecystectomy and appendectomy confirm a 35–60 % relative reduction in surgical-site bleeding and a two-to-threefold decrease in accidental visceral injury when procedures are completed laparoscopically, even in inflamed or contaminated fields [2, 5, 17, 36]. Large multicentre trials in incisional hernia repair and hysterectomy further illustrate that conversion to an open approach occurs in fewer than 6 % of cases and is usually precipitated by dense adhesions or uncontrolled haemorrhage rather than tactile limitations of the technique [16, 30].

5.2 Post-operative Pain, Functional Recovery, and Length of Stay

Patient-centred metrics favour laparoscopy across all specialties. Randomised data in elderly inguinal-hernia patients document a 30–40 % reduction in early pain scores and a median two-day earlier return to baseline mobility after transabdominal pre-peritoneal repair versus open mesh placement [13, 19]. Similar advantages are reported for laparoscopic donor nephrectomy, where enhanced mobilisation and reduced opioid requirements allow routine discharge on post-operative day 2 without increasing readmissions [26]. Enhanced-recovery protocols magnify these gains: restrictive fluid management in gastric cancer surgery halves pulmonary complication rates [4], and ERAS pathways in hysterectomy shorten length of stay by 22 h while maintaining patient satisfaction [27]. Systematic review of structured peri-operative education shows that tailored coaching reduces unscheduled consultations by one third and further accelerates discharge readiness [1].

5.3 Long-Term Outcomes and Recurrence

Oncological durability is preserved after minimally invasive resection. Three-year analyses of obstructive colorectal cancer reveal identical disease-free survival in laparoscopic and open cohorts, with a 41 % relative reduction in incisional hernia formation in the minimally invasive arm [3]. Comparable findings emerge from early-stage cervical cancer, where laparoscopic radical hysterectomy matches open surgery for recurrence and overall survival at five years [9]. In abdominal-wall reconstruction, a multicentre RCT reports non-inferior incisional-hernia recurrence at 36 months after laparoscopic versus open repair despite markedly lower wound-infection rates in the laparoscopic group [16]. Bariatric patients maintain ≥ 50 % excess-weight loss and durable type-2-diabetes remission five years after sleeve gastrectomy or Roux-en-Y gastric bypass, irrespective of age, when procedures are performed laparoscopically within multidisciplinary follow-up pathways [15, 18, 24].

5.4 Quality of Life and Patient-Reported Outcomes

Studies incorporating validated health-related quality-of-life (HRQoL) instruments consistently demonstrate superior early scores after laparoscopic surgery. Single-port distal gastrectomy yields higher global health and body-image indices through three years versus multi-port access [10]. Prospective appendectomy cohorts regain baseline physical-function domains within 14 days post-laparoscopy, compared with 21 days after open surgery [14, 23]. Long-term gynaecologic data reveal that women undergoing laparoscopic myomectomy or hysterectomy experience lower chronic pain prevalence and higher sexual-function scores than those treated via laparotomy [25, 28, 31]. Frail patients benefit similarly: minimally invasive emergency hernia repair is associated with an 18-point mean improvement in the EQ-5D utility index at 90 days relative to open repair, highlighting the value of reduced physiological stress in vulnerable populations [8].

6. Laparoscopy in Special Populations and Complex Scenarios

6.1 Elderly and Frail Patients

Physiological reserve and comorbidity traditionally limited the use of minimally invasive techniques in older adults, yet contemporary evidence confirms that laparoscopy attenuates

peri-operative stress precisely where reserve is lowest. In a propensity-matched registry of emergency ventral and groin hernia repairs, frail patients (Clinical Frailty Scale ≥ 5) who underwent a laparoscopic approach experienced 48 % fewer pulmonary complications, a two-day shorter intensive-care stay, and a 4 % absolute reduction in 30-day mortality compared with matched open controls [8]. Randomised trials in elective inguinal hernia repair corroborate these benefits: transabdominal pre-peritoneal repair cut early pain scores by one third and enabled return to unrestricted daily activity two days sooner than Lichtenstein mesh placement in septuagenarians [13]. Similar findings are reported for bilateral repairs, where a totally extraperitoneal technique further decreases postoperative analgesic requirements without raising recurrence risk [19]. Renal-transplant donor series indicate that laparoscopic nephrectomy remains safe in donors aged >60 years, yielding equivalent graft function and donor convalescence compared with younger cohorts [26].

6.2 Paediatric and Adolescent Cohorts

Paediatric adoption of laparoscopy continues to widen. A prospective series of one-step endoscopic retrograde cholangiopancreatography followed by laparoscopic cholecystectomy in children demonstrated 100 % duct-clearance and a median two-day hospital stay, with no bile-duct injuries or re-interventions at 90 days [34]. Meta-analysis combining adolescent and adult data for laparoscopic sleeve gastrectomy confirmed age-independent excess-weight-loss trajectories and comorbidity resolution, supporting earlier surgical intervention when conservative therapy fails [15].

6.3 Emergency Presentations and Technically Difficult Cases

Delay or technical complexity no longer preclude laparoscopy in the acute abdomen. A systematic review of subtotal and total laparoscopic cholecystectomy for complicated acute cholecystitis reported a 5 % conversion rate, 0.4 % bile-duct-injury rate, and a mean postoperative stay of four days—figures superior to historical open benchmarks [2]. Narrative synthesis of more than 600 “difficult” laparoscopic cholecystectomies highlights the value of bailout strategies such as fundus-first dissection and subtotal resection to avoid conversion when encountering hostile Calot’s anatomy [11]. Large-scale audit data confirm that performing acute cholecystectomy laparoscopically during the index admission—regardless of time of day—does not increase morbidity or readmissions [35].

In acute appendicitis, a randomised trial demonstrated that delaying laparoscopic appendectomy up to 24 h did not increase perforation or abscess formation, allowing resource optimisation without safety compromise [23]. Single-incision appendectomy maintains operative safety while delivering superior body-image scores and reduced incision-specific pain in both elective [17] and emergency settings [20], and population-level data verify lower wound-infection rates than open surgery, even among elderly or septic patients [36].

6.4 Patients with Prior Major Surgery or Multimorbidity

Previous extensive operations were once viewed as a contraindication to laparoscopy because of adhesions and altered anatomy. Contemporary evidence refutes this notion: patients undergoing laparoscopic colon resection as their index procedure require fewer adhesiolysis maneuvers and lose less blood when subjected later to cytoreductive surgery and hyperthermic intraperitoneal chemotherapy for metachronous peritoneal metastasis, compared with patients whose primary colon resection was open [6]. Similarly, laparoscopic liver resection after prior gastrectomy carries no excess risk of bile leakage when meticulous adhesiolysis and low-central-venous-pressure parenchymal transection are employed [37].

7. Limitations, Knowledge Gaps, and Future Directions

7.1 Methodological Heterogeneity

Randomised trials, cohort studies, and meta-analyses in laparoscopy continue to employ non-standard definitions of conversion, surgical difficulty, and postoperative morbidity. The INCH multicentre trial defines “surgical site complication” as any wound event within 30 days, whereas the Kanaka meta-analysis of obstructive colorectal cancer restricts this endpoint to Grade ≥ III events on the Clavien–Dindo scale [3, 16]. Mesh-fixation trials report recurrence at 12 months [22], yet incisional-hernia studies demand a minimum 36-month interval [16]. Such variability hinders pooled effect estimation and crowds meta-analyses with statistical heterogeneity. Harmonised core outcome sets—anchored to international consensus definitions—are urgently required.

7.2 Short and Uneven Follow-up

Oncological datasets seldom extend beyond five years, limiting insight into disease-specific survival after minimally invasive gastrectomy [10], colorectal resection [3], and cervical

cancer surgery [9]. Hernia recurrence is often censored at three years [16, 19], despite evidence that mesh degradation and functional failure may manifest later. Bariatric series demonstrate durable excess-weight loss and glycaemic control to year five [15, 18, 24], but equivalent longitudinal data are lacking for fertility after laparoscopic myomectomy [28] and graft function after living-donor nephrectomy [26]. Establishing prospective, procedure-specific registries with ≥10-year surveillance would address this gap.

7.3 Population Imbalance and External Validity

Most high-level studies originate from tertiary centres in high-income countries. Only one prospective investigation focuses on children, evaluating a one-step ERCP-plus-laparoscopic-cholecystectomy strategy [34]. Frailty and multimorbidity are increasingly analysed in hernia repair [8, 13], yet remain understudied in major visceral resections. Evidence in cirrhotic, immunosuppressed, or extreme-BMI patients is fragmentary. Future trials must stratify by age, frailty index, and metabolic status to clarify risk–benefit profiles in these groups.

7.4 Technological Barriers and Learning Curves

High-definition three-dimensional optics improve intracorporeal suturing efficiency and shorten operating time, but acquisition costs remain high and cost-utility analyses are scarce [32]. Robotic articulation enhances complex myomectomy, yet longer docking times and instrument depreciation raise direct procedural costs by 15–30 % compared with laparoscopy [33]. Single-incision access demands a learning curve of 15–30 cases for appendectomy [17, 20] and >40 cases for gastric resection [10], posing credentialling challenges for low-volume centres. Simulation-based curricula and telementoring platforms should be incorporated into surgical training to democratise expertise.

7.5 Economic and System-Level Considerations

Staple-line buttressing and omentopexy reduce haemorrhagic events in sleeve gastrectomy [7] but add single-use consumables; mesh-fixation devices increase supply costs without demonstrable benefit in primary TAPP repair [22]. Living-donor nephrectomy studies show that disposable trocar selection—not operative time—drives cost variation between transperitoneal and retroperitoneal approaches [26, 29]. Comprehensive cost–effectiveness models that integrate direct hospital expenditure with societal productivity gains (e.g., faster return to work after laparoscopic hernia repair [19]) are needed to guide policy.

7.6 Research and Innovation Agenda

1. **Standardised Core Outcome Sets** – Consensus-driven endpoints for each procedure, measured at uniform intervals, to enable meta-analysis and benchmarking [3, 16, 22].

2. **Long-Term Registries** – Multinational, procedure-specific databases capturing ≥10-year oncological, functional, and quality-of-life outcomes [10, 15, 25].

3. **Cost–Utility Trials** – Randomised or prospective evaluations comparing conventional, 3-D, and robotic laparoscopy with formal incremental cost-effectiveness ratios across benign and malignant indications [32, 33].

4. **Equity-Focused Implementation Science** – Pragmatic studies assessing adoption barriers in rural, low-resource, or high-frailty settings, building on early evidence from emergency hernia repair and donor nephrectomy [8, 13, 26].

5. **Digital Integration** – Trials of artificial-intelligence image enhancement, real-time analytics, and structured e-coaching to replicate the benefits of face-to-face peri-operative education demonstrated in a single-centre RCT [1].

6. **Complex-Scenario RCTs** – Trials in cirrhotic, immunosuppressed, and extreme-BMI populations, and paediatric procedures beyond biliary surgery, to define safety margins and optimise protocols [34, 37].

Addressing these priorities will refine the evidence base, enhance value-based decision-making, and ensure that the benefits of minimally invasive surgery are realised across diverse patient populations and healthcare environments.

8. Discussion

The present review consolidates evidence from 37 contemporary studies spanning general, hepatobiliary, bariatric, gynaecologic, and urologic surgery to appraise the current status of laparoscopy and its evolution into an indispensable standard of care. Collectively, the data

confirm a consistent pattern of reduced intra-operative blood loss, lower postoperative pain, faster functional recovery, and shorter length of stay when laparoscopy is compared with open surgery across a spectrum of pathologies [2 – 5, 7, 9, 13, 16, 25]. These benefits are accompanied by equivalent oncologic adequacy in malignant disease and durable functional outcomes in benign conditions, dispelling early concerns that access limitation might compromise radicality or long-term durability [3, 9, 10, 16, 25].

8.1 Mechanisms Underpinning Superior Outcomes

The superiority of laparoscopy appears multifactorial. Reduced peritoneal manipulation and preservation of abdominal-wall integrity attenuate surgical stress and systemic inflammatory response, translating into lower complication rates in both elective and emergency settings [2, 5, 11, 23]. Enhanced visualization—augmented by three-dimensional optics [32]—and fine instrument articulation facilitate meticulous haemostasis and dissection even in complex scenarios such as subtotal cholecystectomy for hostile Calot's triangle [11] or combined colorectal–hepatic resections [12]. Furthermore, adherence to evidence-based peri-operative protocols (restrictive fluid therapy [4] and ERAS pathways [27]) magnifies the inherent physiologic advantages of the minimally invasive approach.

8.2 Expansion of Indications and Patient Populations

The reviewed literature demonstrates a progressive widening of laparoscopic indications. Once limited to uncomplicated gallbladder disease and appendicitis, laparoscopy is now routinely deployed in obstructive colorectal carcinoma after bridging stent placement [3], major hepatectomy in previously operated abdomens [37], complex gynaecologic myomectomy with fertility intent [25, 28, 31, 33], and living-donor nephrectomy [26, 29]. Importantly, frail and elderly patients—historically managed with caution—derive disproportionate benefit from the reduced physiologic insult, as evidenced by lower pulmonary morbidity and shorter intensive-care utilisation after laparoscopic hernia repair [8 13]. Paediatric data, though limited, confirm safety and efficiency in a one-step ERCP-plus-cholecystectomy strategy [34], opening avenues for broader paediatric adoption.

8.3 Technological Refinements and Cost Considerations

Technological advances such as single-incision access [10, 17, 20], 3-D visualisation [32], and adjunctive haemostatic measures [7] enhance operative precision and patient satisfaction.

Nevertheless, their widespread diffusion hinges on demonstrable cost-effectiveness. Current evidence indicates that cost drivers are dominated by consumables and capital investment rather than operative time [26, 29, 32, 33]. Trials eliminating routine mesh fixation in TAPP repair [22] and adopting totally extraperitoneal techniques [19] exemplify how evidence can rationalise resource use without sacrificing outcomes. Comprehensive economic evaluations that integrate direct hospital expenditure and societal productivity gains are now warranted to inform policy and purchasing decisions.

8.4 Remaining Uncertainties

While the trajectory of minimally invasive surgery is unequivocally positive, several gaps persist. Methodological heterogeneity in endpoint definitions complicates cross-study comparison and meta-analysis [3, 16, 22]. Follow-up rarely exceeds five years outside oncologic cohorts, limiting insight into very-long-term recurrence, metabolic relapse, or reproductive outcomes [15, 18, 24, 25, 28]. Evidence is scant for cirrhotic, immunosuppressed, extreme-BMI, and low-resource populations. Moreover, the learning curve associated with advanced technologies demands structured training and telementoring frameworks to ensure safe dissemination [17, 20, 33].

8.5 Clinical Implications

Surgeons should preferentially select laparoscopic approaches for eligible patients, including the elderly, frail, and those requiring complex combined resections, provided institutional expertise and infrastructure are adequate. Adoption should be coupled with standardised peri-operative pathways—including restrictive fluid management in upper-GI surgery [4] and ERAS principles [27]—and patient-education programmes shown to accelerate recovery [1]. Shared decision-making should incorporate discussion of long-term data where available and transparent counselling on the limitations of current evidence in specific subgroups.

8.6 Research Agenda

Future investigations must prioritise: (i) core outcome sets with uniform definitions; (ii) ≥ 10-year registries across specialties; (iii) pragmatic cost-utility trials comparing conventional, 3-D, and robotic platforms; (iv) high-quality studies in under-represented populations, especially paediatric and multimorbid cohorts; and (v) integration of digital innovation—including AI-driven image guidance and tele-education—to democratise access to expertise

and peri-operative coaching [1, 32, 33]. Addressing these priorities will refine value-based surgical care and ensure equitable dissemination of the benefits realised by minimally invasive surgery.

9. Conclusions

Minimally invasive surgery has transitioned from a novel technique to an established standard of care across general, hepatobiliary, bariatric, gynaecologic, and urologic specialties. Current evidence demonstrates that laparoscopic approaches consistently reduce intra-operative trauma, postoperative pain, complication rates, and length of stay while maintaining—or surpassing—oncological and functional outcomes achieved with open surgery. These benefits extend to elderly and frail patients, paediatric cohorts, and complex or emergency scenarios when performed by appropriately trained teams within supportive peri-operative pathways.

Technological refinements—such as three-dimensional imaging, single-incision access, and tailored haemostatic adjuncts—continue to expand indications and improve patient satisfaction. Nevertheless, uniform outcome definitions, longer-term surveillance, robust cost-utility analyses, and inclusive research involving under-represented populations are still required to optimise value and equity in minimally invasive care.

Clinicians should prioritise laparoscopic techniques whenever technically feasible and clinically appropriate, integrating evidence-based anaesthetic strategies, enhanced-recovery protocols, and structured patient education to maximise benefits. Concurrently, healthcare systems must invest in surgeon training, quality-assurance frameworks, and pragmatic research to close remaining knowledge gaps and ensure that the advantages of modern laparoscopy are realised universally.

Disclosure

Author Contributions

Conceptualization: Maksymilian Czarnota

Methodology: Martyna Adamowicz

Software: Martyna Adamowicz

Formal analysis: Aleksandra Górniak

Investigation: Aleksandra Górniak

Resources:Maksymilian Czarnota

Check: Aleksandra Górniak

Writing -rough preparation: Martyna Adamowicz

Writing -review and editing: Martyna Adamowicz

Supervision: Maksymilian Czarnota

Visualization: Maksymilian Czarnota

All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Data sharing is not applicable to this article.

Conflict of interest

The authors declare no conflict of interest.

References

1. Maheta B, Shehabat M, Khalil R, Wen J, Karabala M, Manhas P, Niu A, Goswami C, Frezza E. The Effectiveness of Patient Education on Laparoscopic Surgery Postoperative Outcomes to Determine Whether Direct Coaching Is the Best Approach: Systematic Review of Randomized Controlled Trials. JMIR Perioper Med. 2024 Jun 27;7:e51573. doi: 10.2196/51573. PMID: 38935953; PMCID: PMC11240078.

2. Martinez B, Breeding T, Katz J, Kostov A, Santos RG, Ibrahim J, Elkbuli A. Evaluating Clinical Outcomes of Laparoscopic Subtotal and Total Cholecystectomy for Complicated Acute Cholecystitis: A Systematic Review and Meta-Analysis. Am Surg. 2024 Mar;90(3):436-444. doi: 10.1177/00031348231216482. Epub 2023 Nov 15. PMID: 37966455.

3.Kanaka S, Yamada T, Matsuda A, Uehara K, Shinji S, Yokoyama Y, Takahashi G, Iwai T, Takeda K, Kuriyama S, Miyasaka T, Yoshida H. Short-term and three-year long-term outcomes of laparoscopic surgery versus open surgery for obstructive colorectal cancer following self-expandable metallic stent placement: a meta-analysis. Surg Endosc. 2024

Oct;38(10):5514-5527. doi: 10.1007/s00464-024-11187-x. Epub 2024 Aug 29. PMID: 39210057; PMCID: PMC11458689.

4.Kusaka Y, Ueno T, Minami T. Effect of restrictive versus liberal fluid therapy for laparoscopic gastric surgery on postoperative complications: a randomized controlled trial. J Anesth. 2025 Feb;39(1):101-110. doi: 10.1007/s00540-024-03439-w. Epub 2024 Dec 16. PMID: 39680086; PMCID: PMC11782308.

5.Roy DK, Sheikh R. A Systematic Review and Meta-Analysis of the Outcomes of Laparoscopic Cholecystectomy Compared to the Open Procedure in Patients with Gallbladder Disease. Avicenna J Med. 2024 Feb 1;14(1):3-21. doi: 10.1055/s-0043-1777710. PMID: 38694141; PMCID: PMC11057899.

6.Nevo Y, Assaf D, Jacover A, Katz E, Ben-Yaacov A, Hazzan D, Laks S, Adileh M, Nissan A. The impact of laparoscopic vs open primary colon resection on long-term outcomes after subsequent cytoreductive surgery (CRS) and hyperthermic intraperitoneal chemotherapy (HIPEC) for metachronous peritoneal metastasis. Surg Endosc. 2025 May 16. doi: 10.1007/s00464-025-11798-y. Epub ahead of print. PMID: 40379853.

7.Demirpolat MT, Islam MM, Bacaksiz ME, Ertekin SC, Sisik A. Comparison of Early Postoperative Outcomes of Omentopexy and Clips along the Staple Line During Laparoscopic Sleeve Gastrectomy: A Randomized Study. Obes Surg. 2024 Nov;34(11):4116-4124. doi: 10.1007/s11695-024-07543-4. Epub 2024 Oct 12. PMID: 39395146.

8.Distler A, Salas Parra R, Huang X, Ahmed H, Barrera R, Patel V, Hansen L. Minimally Invasive Surgery Benefits Frail Patients Undergoing Emergency Hernia Repairs. JSLS. 2025 Jan-Mar;29(1):e2024.00049. doi: 10.4293/JSLS.2024.00049. Epub 2025 Mar 25. PMID: 40144386; PMCID: PMC11935647.

9.Zhao J, Liu Q, Jiang D, Chen T, Meng S, Shu C. Comparative study of tumor-free laparoscopic and open surgery in the treatment of early-stage cervical cancer. Zhong Nan Da Xue Xue Bao Yi Xue Ban. 2023 Nov 28;48(11):1686-1695. doi: 10.11817/j.issn.1672-7347.2023.230334. PMID: 38432859; PMCID: PMC10929954.

10.Fujita K, Omori T, Hara H, Shinno N, Yasui M, Wada H, Akita H, Ohue M, Miyata H, Takiguchi S. Three-year follow-up outcomes of postoperative quality of life from a randomized controlled trial comparing multi-port versus single-port laparoscopic distal gastrectomy. Surg Endosc. 2025 Jan;39(1):269-279. doi: 10.1007/s00464-024-11213-y. Epub 2024 Nov 11. PMID: 39528658.

11.Abdallah HS, Sedky MH, Sedky ZH. The difficult laparoscopic cholecystectomy: a narrative review. BMC Surg. 2025 Apr 12;25(1):156. doi: 10.1186/s12893-025-02847-3. PMID: 40221716; PMCID: PMC11992859.

12.Boudiaf Z, Bouzid C, Cherchar K, Chibane A, Kheloufi M, Boutekedjiret IH, Hattou Z, Bentabak K. Outcomes of Laparoscopic Combined Surgery for Colorectal Cancer with Synchronous Liver Metastases: A Prospective Comparative Study. Gulf J Oncolog. 2022 May;1(39):47-55. PMID: 35695346.

13.Ulutas ME, Yilmaz AH. Comparison of open and laparoscopic inguinal hernia repair in the elderly patients: a randomized controlled trial. Hernia. 2025 May 23;29(1):179. doi: 10.1007/s10029-025-03368-x. PMID: 40407912; PMCID: PMC12101994.

14.Hougaard ES, Møller LK, Kristensen SAR, Høyer ME, Ellebaek MB, Al-Najami I. Patient reported outcomes after laparoscopic appendectomy for acute appendicitis. Langenbecks Arch Surg. 2024 Dec 24;410(1):15. doi: 10.1007/s00423-024-03584-6. PMID: 39718656.

15.Karasko D. A systematic review and meta-analysis combining adolescent and adult data to evaluate weight loss and the effect of age following the laparoscopic sleeve gastrectomy. Obes Rev. 2024 Sep;25(9):e13770. doi: 10.1111/obr.13770. Epub 2024 May 28. PMID: 38804033.

16.van Veenendaal N, Poelman M, Apers J, Cense H, Schreurs H, Sonneveld E, van der Velde S, Bonjer J. The INCH-trial: a multicenter randomized controlled trial comparing short- and long-term outcomes of open and laparoscopic surgery for incisional hernia repair. Surg Endosc. 2023 Dec;37(12):9147-9158. doi: 10.1007/s00464-023-10446-7. Epub 2023 Oct 9. PMID: 37814167; PMCID: PMC10709221.

17.Kossenas K, Kouzeiha R, Moutzouri O, Georgopoulos F. Single-incision versus conventional laparoscopic appendectomy in adults: a systematic review and meta-analysis of randomized controlled trials. Updates Surg. 2025 Apr;77(2):287-296. doi: 10.1007/s13304-025-02112-5. Epub 2025 Feb 4. PMID: 39904954; PMCID: PMC11961530.

18.Huang QS, Huang LB, Zhao R, Yang L, Zhou ZG. Comparing the effects of laparoscopic Roux-en-Y gastric bypass versus laparoscopic sleeve gastrectomy on weight loss and comorbidity resolution: A systematic review and meta-analysis. Asian J Surg. 2024 Oct 10:S1015-9584(24)02198-5. doi: 10.1016/j.asjsur.2024.09.153. Epub ahead of print. PMID: 39393960.

19.Şenol Z. Evaluation of Surgical Results and Effectiveness of Laparoscopic Transabdominal Preperitoneal and Laparoscopic Totally Extraperitoneal Approaches in Bilateral Inguinal Hernia Repair: A Randomized Analysis. J Laparoendosc Adv Surg Tech A. 2025 Feb;35(2):152-155. doi: 10.1089/lap.2024.0360. Epub 2024 Nov 8. PMID: 39515379.

20.Kohama S, Nagakari K, Ohuchi M, Takehara K, Honjo K, Ishiyama S, Sugimoto K, Oka S, Yoshimoto J, Fukunaga M, Ishizaki Y, Sakamoto K. Clinical Outcomes of Single-incision Laparoscopic Appendectomy Versus Conventional Laparoscopic Appendectomy in Adult Acute Appendicitis. Juntendo Iji Zasshi. 2024 Dec 31;70(6):436-444. doi: 10.14789/ejmj.JMJ24-0032-OA. PMID: 39840002; PMCID: PMC11745828.

21.Eminoglu L. PRESENTATION AND OUTCOMES OF LAPAROSCOPIC NISSEN FUNDOPLICATIONS. Pol Przegl Chir. 2022 Oct 24;95(4):1-5. doi: 10.5604/01.3001.0016.0660. PMID: 36808067.

22.Riemenschneider KA, Lund H, Pommergaard HC. No evidence for fixation of mesh in laparoscopic transabdominal preperitoneal (TAPP) inguinal hernia repair: a systematic review and meta-analysis of randomized controlled trials. Surg Endosc. 2023 Nov;37(11):8291-8300. doi: 10.1007/s00464-023-10237-0. Epub 2023 Sep 6. PMID: 37674053; PMCID: PMC10615908.

23.Patel SV, Zhang L, Mir ZM, Lemke M, Leeper WR, Allen LJ, Walser E, Vogt K. Delayed Versus Early Laparoscopic Appendectomy for Adult Patients With Acute Appendicitis: A Randomized Controlled Trial. Ann Surg. 2024 Jan 1;279(1):88-93. doi: 10.1097/SLA.0000000000005996. Epub 2023 Jul 13. PMID: 37436871.

24.Bindal V, Agarwal P, Khaitan M, Prasad A, Peters ANC, Narwaria M, Wadhawan R, Shah S, Kular KS, Raj PP, Bhasker AG, Pandey D, Gupta S, Mansuri N, Dhagat D, Jaithlia H, Siddiqui D, Arora B, Singh A. An Indian multicentre real-world study on long-term quality of life outcomes following bariatric surgery. Clin Obes. 2024 Dec;14(6):e12693. doi: 10.1111/cob.12693. Epub 2024 Jul 25. PMID: 39054635.

25.Giannini A, Cuccu I, D'Auge TG, De Angelis E, Laganà AS, Chiantera V, Caserta D, Vitale SG, Muzii L, D'Oria O, Perniola G, Bogani G, Di Donato V. The great debate: Surgical outcomes of laparoscopic versus laparotomic myomectomy. A meta-analysis to critically evaluate current evidence and look over the horizon. Eur J Obstet Gynecol Reprod Biol. 2024 Jun;297:50-58. doi: 10.1016/j.ejogrb.2024.03.045. Epub 2024 Apr 1. PMID: 38581885.

26.Jackson S, Combes A, Latif E, Tran M, Lam S, Gore N, Utsiwegota M, Mawson J, Smith L, Palma C, Laurence J, Crawford M, Pulitano C, Wyburn K, Chadban S, Leslie S, Vasilaras A. Laparoscopic donor nephrectomy-Technique and peri-operative outcomes in an Australian transplant center. Clin Transplant. 2023 May;37(5):e14945. doi: 10.1111/ctr.14945. Epub 2023 Feb 27. PMID: 36807636.

27.Erkan C, Inal HA, Uysal A. Intra- and post-operative outcomes of the Enhanced Recovery after Surgery (ERAS) Program in laparoscopic hysterectomy. Arch Gynecol Obstet. 2024 Jun;309(6):2751-2759. doi: 10.1007/s00404-024-07469-3. Epub 2024 Apr 8. PMID: 38584246.

28.Balulescu L, Brasoveanu S, Pirtea M, Grigoras D, Secoșan C, Olaru F, Erdelean D, Margan MM, Alexandru A, Ivan CS, Pirtea L. The Impact of Laparoscopic Myomectomy on Pregnancy Outcomes: A Systematic Review. J Pers Med. 2024 Mar 25;14(4):340. doi: 10.3390/jpm14040340. PMID: 38672967; PMCID: PMC11051497.

29.Noguchi H, Shingaki K, Sato Y, Kubo S, Kaku K, Okabe Y, Nakamura M. Outcomes and Cost Comparison of 3 Different Laparoscopic Approach for Living Donor Nephrectomy: A Retrospective, Single-Center, Inverse Probability of Treatment Weighting Analysis of 551 Cases. Transplant Proc. 2024 Apr;56(3):482-487. doi: 10.1016/j.transproceed.2024.01.009. Epub 2024 Feb 7. PMID: 38331594.

30.Dedden SJ, Maas JWM, Smeets NAC, van Hamont D, Groenman FA, Lim AC, van Vliet HAAM, van der Steeg JW, Leemans JC, Meijer P, van Kuijk SMJ, Huirne JAF, Bongers MY, Geomini PMAJ. Same-day discharge after laparoscopic hysterectomy for benign/premalignant disease: A multicentre randomised controlled trial. BJOG. 2024 Dec;131(13):1762-1770. doi: 10.1111/1471-0528.17911. Epub 2024 Jul 17. PMID: 39020078.

31.Casarin J, Giudici A, Pinelli C, Lembo A, Ambrosoli AL, Cromi A, Ghezzi F. Surgical Outcomes and Complications of Myomectomy: A Prospective Cohort Study. J Minim Invasive Gynecol. 2024 Jun;31(6):525-532. doi: 10.1016/j.jmig.2024.03.015. Epub 2024 Mar 29. PMID: 38556248.

32.Romanò G, Klarskov N, Lassen PD, Bennich G, Hoffmann E. 3-Dimensional versus standard 2-D laparoscopy for benign hysterectomy: A randomized clinical trial. Eur J Obstet Gynecol Reprod Biol. 2024 Jul;298:187-191. doi: 10.1016/j.ejogrb.2024.05.017. Epub 2024 May 17. PMID: 38781785.

33.Chen W, Ma J, Yang Z, Han X, Hu C, Wang H, Peng Y, Zhang L, Jiang B. Robotic-assisted laparoscopic versus abdominal and laparoscopic myomectomy: A systematic review and meta-analysis. Int J Gynaecol Obstet. 2024 Sep;166(3):994-1005. doi: 10.1002/ijgo.15485. Epub 2024 Apr 8. PMID: 38588036.

34.Santángelo A, Scarpin A, Imaz F, Marino P, Vargas RE, Cardozo Bidart LA, Darrigran S, Macias MA, Sánchez de Loria J, Volonté P, Salgueiro F. One-step endoscopic retrograde cholangiopancreatography and laparoscopic cholecystectomy: A safe strategy in pediatrics. Cir Pediatr. 2025 Apr 7;38(2):45-49. English, Spanish. doi: 10.54847/cp.2025.02.12. PMID: 40196878.

35.Tóth I, Benkő R, Matuz M, Váczi D, Andrási L, Libor L, Tajti J Jr, Lázár G, Ábrahám S. Evaluating Surgical Outcomes in Acute Cholecystectomies. JSLS. 2025 Jan-Mar;29(1):e2024.00061. doi: 10.4293/JSLS.2024.00061. Epub 2025 Apr 8. PMID: 40201579; PMCID: PMC11975552.

36.Bulut A, Ucar M. Laparoscopic Appendectomy versus Open Surgery. JSLS. 2025 Jan-Mar;29(1):e2024.00077. doi: 10.4293/JSLS.2024.00077. Epub 2025 Apr 7. PMID: 40196192; PMCID: PMC11973471.

37.Ide T, Ito K, Tanaka T, Noshiro H. Influence of previous gastrectomy on postoperative bile leakage after laparoscopic liver resection. BMC Surg. 2025 Apr 7;25(1):139. doi: 10.1186/s12893-025-02873-1. PMID: 40189533; PMCID: PMC11974140.