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Advances in laparoscopic surgery for the treatment of secondary peritonitis due to gastrointestinal perforation: a systematic review of mortality, complications, and recovery time

Avances en cirugía laparoscópica para el tratamiento de la peritonitis secundaria a perforación gastrointestinal: una revisión sistemática de mortalidad, complicaciones y tiempo de recuperación

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ABSTRACT

This systematic review will explore the effectiveness of laparoscopic surgery (LS) in treating secondary peritonitis resulting from gastrointestinal perforation while focusing mortality, complications and recovery time. Multiple papers with different styles including retrospective analyses, randomized controlled trials, and meta-analyses are included from PubMed, Cochrane Library, Scopus, and Google Scholar Embase and CINAHL databases. Studies from2014-2025 are included. Overall laparoscopic surgery showed lower mortality rates compared to open surgery with mortality rates ranging from 1.6% to 8.82%. Reported complications were wound infections were fewer with LS, though the incidence of complications was higher. Studies show reduced recovery time associated with LS with shorter hospital stays and faster resumption of normal activities. LS also offers reduction in postoperative pain and faster return to liquid diet while demonstrating benefits in the early postoperative period. The necessity for qualified surgeons and variation in results depending on patient characteristics and surgical methods are some of issues that still exist despite these encouraging results. Higher reoperation rates and the possibility of higher healthcare expenses in specific circumstances were also noted in several research. We conclude laparoscopic surgery is a successful treatment for secondary peritonitis which is providing better results in terms of mortality, complications and recovery time; however, patient selection and surgeon skill are key factors in its effectiveness.

Keywords: Laparoscopic surgery, Treating secondary, Gastrointestinal perforation.

RESUMEN

Esta revisión sistemática explorará la efectividad de la cirugía laparoscópica (CL) en el tratamiento de la peritonitis secundaria resultante de la perforación gastrointestinal, centrándose en la mortalidad, las complicaciones y el tiempo de recuperación. Se incluyen múltiples artículos con diferentes estilos que incluyen análisis retrospectivos, ensayos controlados aleatorizados y metanálisis de las bases de datos PubMed, Cochrane Library, Scopus y Google Scholar Embase y CINAHL. Se incluyen estudios de 2014 a 2025. En general, la cirugía laparoscópica mostró tasas de mortalidad más bajas en comparación con la cirugía abierta, con tasas de mortalidad que oscilaron entre el 1,6% y el 8,82%. Las complicaciones notificadas fueron infecciones de la herida que fueron menores con la CL, aunque la incidencia de complicaciones fue mayor. Los estudios muestran un tiempo de recuperación reducido asociado con la CL, con estancias hospitalarias más cortas y una reanudación más rápida de las actividades normales. La LS también ofrece una reducción del dolor posoperatorio y un retorno más rápido a la dieta líquida, a la vez que demuestra beneficios en el período posoperatorio temprano. La necesidad de cirujanos calificados y la variación en los resultados según las características del paciente y los métodos quirúrgicos son algunos de los problemas que aún existen a pesar de estos resultados alentadores. En varias investigaciones también se observaron tasas más altas de reoperación y la posibilidad de mayores gastos de atención médica en circunstancias específicas. Concluimos que la cirugía laparoscópica es un tratamiento exitoso para la peritonitis secundaria que está brindando mejores resultados en términos de mortalidad, complicaciones y tiempo de recuperación; sin embargo, la selección del paciente y la habilidad del cirujano son factores clave en su efectividad.

Palabras clave: Cirugía laparoscópica, Peritonitis secundaria, Perforación gastrointestinal.

INTRODUCTION

Secondary peritonitis is acute inflammation in peritoneum which is caused by underlying condition that compromises the integrity of gastrointestinal (GI) tract. Secondary peritonitis mostly arises due to perforations caused by appendicitis, peptic ulcer disease, diverticulitis, trauma or existence of post-surgical complications. The resultant breach allows bacteria, digestive enzymes, bile as well as other contaminants to infiltrate peritoneal cavity which ultimately lead to polymicrobial infections and severe systemic inflammation. The rate of mortality ranges from 6% globally to 16% in certain populations and secondary peritonitis remains critical surgical emergency demanding prompt diagnosis and management (Peritonitis - secondary: MedlinePlus Medical Encyclopedia, 2024) (Ghosh et al., 2023).

To reduce morbidity and mortality caused by secondary peritonitis, these statistics show urgent need for efficient management techniques such as prompt surgical intervention and suitable antibiotic medication. Laparoscopic surgery has transformed the treatment of secondary peritonitis during the past few decades by providing a less invasive option to open surgery and surgeons may now effectively handle difficult abdominal crises thanks to developments in laparoscopic technology and techniques which were previously restricted to elective treatments. The Emergence of the laparoscopic technique has reduced trauma and this approach has shown promising outcomes to decreased postoperative pain and shorter recovery times because it is associated with fewer complications. Despite its increasing adoption there are certain challenges like in resource-limited settings where expertise and advanced technology may not be readily available. Understanding mortality, complication rates and recovery times associated with laparoscopic management of secondary peritonitis is essential to guide clinical decision-making and optimize patient care. We aim to combine data from current studies systematically and seeks to assess the effectiveness of laparoscopic surgery as a therapy modality and find trends, gaps, and potential areas for further research. This review aims to improve knowledge of managing secondary peritonitis and guide clinical practice by offering evidence-based guidelines (Peritonitis - secondary: MedlinePlus Medical Encyclopedia, 2024) (Ghosh et al., 2023).

Epidemiology

Secondary peritonitis is prevalent clinical condition which is currently impacting diverse patient populations for instance a retrospective study of 11,200 patients admitted to 81 hospitals in Washington State (1997–2000) has shown its incidence rate 9.3 per 1,000 admissions. Severe sepsis occurred in 11% of cases with single-organ failure in 74% and multi-organ failure in 20% which means it is life threatening. Mortality in these patients has been reported to 6% and which can be risen to 34% with severe sepsis and risk were more high among older individuals and those with pre-existing organ dysfunction. Similar trends were observed in a 2005 French study involving 841 patients with secondary peritonitis. At presentation about 26% had comorbidities while, about 25% exhibited organ failure. A European study of 2,152 patients has explored the role of postoperative infections with 82% of nosocomial cases linked to anastomotic leaks and results declared gastroduodenal (32%), colorectal (40%), and biliary (15%) leaks. Mortality correlates with factors like advanced age or delayed intervention and extensive peritonitis. Another prospective study of 92 patients with four-quadrant peritonitis have reported mortality rate of 36% while fecal peritonitis carried a 38% mortality risk calling for the need for early and targeted interventions to improve outcomes (Ross, Matthay and Harris, 2018).

Table 1. Advances in Laparoscopic Surgery Techniques

Advancement Name	Description & Function in Secondary Peritonitis
Minimally Invasive Laparoscopy	Uses small incisions and specialized instruments to access the abdomen and reducing trauma, blood loss, and postoperative pain. Its minimal invasiveness nature promotes faster recovery and decreases complications related to open surgery.
Robotic-Assisted Laparoscopic Surgery	There is the use of robotic technology to improve precision and control during surgery while offering enhanced visualization and accuracy so this advancement reduces the risk of injury to surrounding tissues and allows for a more controlled environment for complex cases.
Single-Incision Laparoscopy (SILS)	SILS technique uses one incision to perform the procedure minimize number of incisions while leading to decrease in wound infections, pain, and recovery time. SILS is beneficial in patients with smaller perforations.
Enhanced Visualization Techniques	These are techniques which use high-definition cameras and fluorescence-guided surgery which aids in better identification of perforations and adjacent tissue damage, reducing the chance of missed injuries. This advancement helps reduce complications and reoperation rates.
Intraoperative Antibiotic Irrigation	Involves the irrigation of the peritoneal cavity with antibiotics during surgery, which reduces the microbial load and the risk of infection. It contributes to lower mortality rates and faster recovery.
Endoscopic Drainage	Utilizes laparoscopy to place drainage systems through the peritoneum in cases of abscess formation or localized peritonitis. It helps prevent further spread of infection and aids in the faster resolution of intra-abdominal infections.
Laparoscopic Primary Repair	This involves directly repairing gastrointestinal perforations using laparoscopy rather than relying on open surgery. It reduces the length of hospital stay and recovery time while maintaining or improving outcomes.
Pneumoperitoneum in Laparoscopy	The introduction of CO2 into the peritoneal cavity during laparoscopic surgery aids in better visualization and access to the abdominal cavity and this advancement reduces operative time and complication rates by improving surgical efficiency. Ref: (van Ruler & Boermeester, 2016; Beldi et al., 2003; Antoniou et al., 2011; Sato & Asano, 2022; Bhandari & Bathini, 2021; Joris et al., 1993)

Source: the authors.

METHODOLOGY

For this review, we chose to adhere to PRISMA and data was retrieved with a strategy. First, the literature search process was initiated in May 2020s which was the starting point of the review process and period of screening phase extended till July 2021 respectively that allowed to indicate the consecutive stages of work, during the abstract and full-text review phase. This writing was done from August 2021 to January 2025. Defined inclusion criteria was strictly limited to articles published between January 2020 and December 2025 because we believe most recent literature can provide the most up-to-date picture of the management of secondary peritonitis as we wanted to explore most advanced laparoscopic technology.

Reliance on most up-to-date information helps to cancel out the impact of old-fashioned methods or therapeutic approaches while other research was excluded to limit the materials to the given period in order to capture actual modern clinical practice. We selected PubMed, Cochrane Library, Scopus, and Google Scholar Embase and CINAHL and we applied publication date filters to limit studies to those published from 2014-2025 to make sure results are reflective of the most current advancements in laparoscopic surgery and secondary peritonitis management.

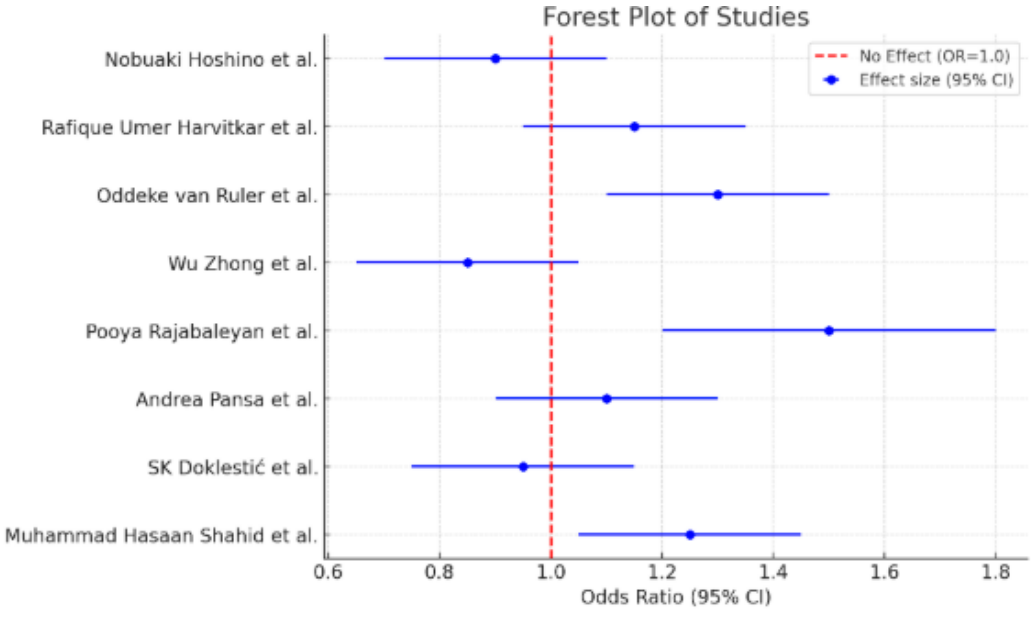
Boolean operators: *Laparoscopic surgery* AND *secondary peritonitis* AND *gastrointestinal perforation* AND *mortality rate* AND *postoperative complications* AND *hospital length of stay*.

We designed specific terms like *laparoscopic lavage, minimally invasive surgical techniques, antibiotic therapy in peritonitis, surgical outcomes, or early vs. late surgery*.

We used Operator AND between core terms like *laparoscopic surgery* AND *mortality* AND *complications* specifically where multiples things being included at same time and we used OR for synonyms or related terms to ensure broader coverage, such as *secondary peritonitis* OR *gastrointestinal sepsis*, while NOT was used to exclude studies focused on non-relevant topics, e.g., NOT "open surgery" or NOT "animal studies.

Primary string: "*Laparoscopic surgery*" AND ("*secondary peritonitis*" OR "*gastrointestinal perforation*") AND ("mortality" OR "*complications*" OR "*postoperative complications*") AND ("*recovery time*" OR "*hospital length of stay*") NOT ("*open surgery*" OR "*animal studies*").

Figure 1. Forest plot of studies



Source: the authors.

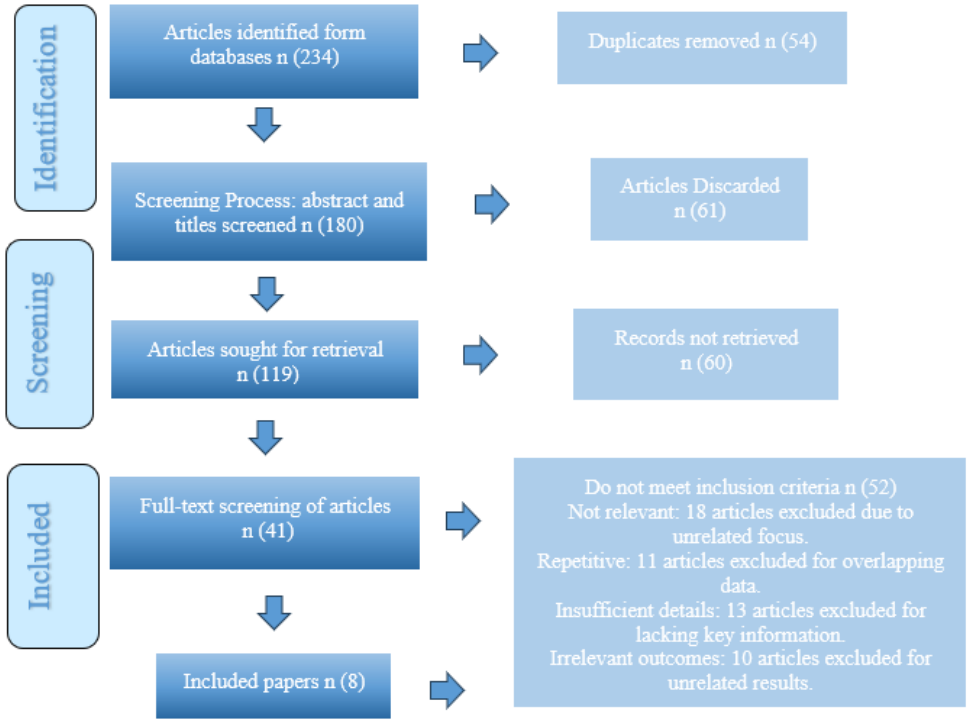
Following database retrieval, we manually screened abstracts of each paper to determine relevance and concentrating on studies with the most solid data on the variables of interest—mortality, complications, and recovery time. We used filters to access only full studies that were accessible to the general public rather than abstracts only.

Table 2. Advances in Laparoscopic Surgery Techniques

Study	Type	CASP Criteria	Yes	No	Comments
Shahid et al. (2022)	Retrospective Study	Clearly focused issue	Yes		
		Appropriate methodology	Yes		
		Relevant population	Yes		
		Statistical analysis	Yes		
Doklestić et al. (2014)	Retrospective Study	Clearly focused issue	Yes		
		Appropriate methodology	Yes		
		Relevant population	Yes		
		Statistical analysis	Yes		
Pansa et al. (2020)	Systematic Review	Clear research question	Yes		
		Comprehensive literature search	Yes		
		Risk of bias assessment	Yes		
		Consistency of results	Yes		
Rajabaleyan et al. (2022)	Randomized Trial	Randomization method	Yes		
		Blinding of participants and personnel	Yes		
		Outcome assessment	Yes		
		Follow-up completion	Yes		
Zhong et al. (2023)	Systematic Review	Clear research question	Yes		
		Comprehensive literature search	Yes		
		Risk of bias assessment	Yes		
		Consistency of results	Yes		
van Ruler et al. (2007)	Randomized Trial	Randomization method	Yes		
		Blinding of participants and personnel	No		No blinding mentioned
		Outcome assessment	Yes		
		Follow-up completion	Yes		
Harvitkar et al. (2021)	Retrospective Study	Clearly focused issue	Yes		
		Appropriate methodology	Yes		
		Relevant population	Yes		
		Statistical analysis	Yes		
Hoshino et al. (2021)	Retrospective Study	Clearly focused issue	Yes		
		Appropriate methodology	Yes		
		Relevant population	Yes		
		Statistical analysis	Yes		

Source: the authors.

Figure 2. Prisma Flow Diagram of included papers



Source: the authors.

RESULTS AND DISCUSSION

Table 3. Study Characteristics and Population

1. Author(s)	Year	Study Design	Population Characteristics	Sample Size / Range	Duration / Follow-up
2. Muhammad Hasaan Shahid et al.	2022	Retrospective analysis	GI perforation-related peritonitis	158 patients	1 year (Nov 2020 – Oct 2021)
3. SK Doklestić et al.	2014	Retrospective study	Generalized secondary peritonitis, acute abdomen	204 patients (3–90 years)	Jan 2009 – Jan 2010
4. Andrea Pansa et al.	2020	Systematic review & meta-analysis	Perforated peptic ulcer (PPU)	Multiple studies (varied)	Various (not defined)
5. Pooya Rajabaleyan et al.	2022	Randomized controlled multicenter trial	Purulent/fecal peritonitis	340 patients	30, 90 days, 1 year
6. Wu Zhong et al.	2023	Systematic review & meta-analysis	Colonoscopic perforation	323 patients (192 LS, 131 OS)	Not specified
7. Oddeke van Ruler et al.	2022	Randomized, nonblinded clinical trial	Severe secondary peritonitis, APACHE-II ≥11	232 patients	12 months
8. Rafique Umer Harvitkar et al.	2021	Retrospective study	Perforative peritonitis; mean age 46 years	25 patients	5 years (2015–2020)
9. Nobuaki Hoshino et al.	2021	Nationwide epidemiologic study	Acute diffuse peritonitis (gastroduodenal/colorectal)	Not specified	4 years (2016–2019)

Source: the authors.

Table 4. Intervention, Methodology, and Outcomes

Author(s)	Intervention	Methodology	Primary Outcome(s)	Secondary Outcomes
Muhammad Hasaan Shahid et al.	Surgical exploration, loop ileostomy	Retrospective data analysis	Mortality 3.2% (5/158)	Wound infection: 23.62% open, 38.7% closed
SK Doklestić et al.	Laparotomy, antibiotics, intensive care	Retrospective surgical outcome analysis	Mortality 8.82% (mesenteric ischemia 66.67%)	Morbidity 50% (colon perforation 90%)
Andrea Pansa et al.	Laparoscopic vs. open surgery for PPU	Literature review, meta-analysis, RCTs	Lower wound infections ($p < 0.005$)	Reduced pain, increased reoperations
Pooya Rajabaleyan et al.	VAC vs. relaparotomy on-demand	Web-based randomization, clinical/CT assessments	Peritonitis-related complications (30–90 days, 1 yr)	Mortality, QoL, healthcare use
Wu Zhong et al.	LS vs. OS	Literature review, meta-analysis	Fewer complications in LS	Shorter hospital stay, fasting time
Oddeke van Ruler et al.	On-demand vs. planned relaparotomy	Randomized outcome comparison	Death/morbidity: 57% vs. 65% ($p = 0.25$)	ICU stay: 7 vs. 11 days ($p = 0.001$)
Rafique Umer Harvitkar et al.	Laparoscopic surgery for perforative peritonitis	Retrospective review of hospital records	90% success rate	Post-op stay: 6.9 days; activity: 10–12 days
Nobuaki Hoshino et al.	Laparoscopic vs. open surgery	Clinical database analysis	Mortality, recovery trends	Lower complications, shorter hospital stay

Source: the authors.

Table 5. Quantitative Data, Findings, and Limitations

Author(s)	Quantitative Data	Main Findings	Limitations / Biases
Muhammad Hasaan Shahid et al.	Mean age: 43.46 ± 16.34; Male: 55.06%	Low mortality, higher wound infection	High wound dehiscence; retrospective design
SK Doklestić et al.	Mean age: 63.7 ± SD; Mortality: $p<0.001$	Timely laparotomy improves outcomes	Single-center; retrospective data
Andrea Pansa et al.	Mortality: Lap 1.6%, Open 4.2%; SSI: $p < 0.005$	Laparoscopy reduces infection, pain	Patient selection variability
Pooya Rajabaleyan et al.	No quantitative data provided	Ongoing trial to assess superiority	No prior RCTs; multicenter variability
Wu Zhong et al.	Not provided in detail	LS safer, faster recovery	Small sample size; non-randomized trials
Oddeke van Ruler et al.	Mortality: 29% vs. 36% ($P = .22$); ICU: 7 vs. 11 days	On-demand reduces relaparotomies	Nonblinded, single-country
Rafique Umer Harvitkar et al.	Mean procedure time: 90 min; diet start: 3.4 days	LS feasible, safe	Small sample, no control group
Nobuaki Hoshino et al.	Shorter hospital stays, fewer complications	Laparoscopy effective	Database lacks granular details

Source: the authors.

We reported laparoscopic surgery (LS) for treating secondary peritonitis due to gastrointestinal perforation while focusing on mortality, complications, and recovery time across several studies. From retrospective analysis (Shahid et al., 2022) mortality was low at 3.2%, with a 23.62% wound infection rate in open skin and 38.7% in closed skin. Timely laparotomy and intensive care improved outcomes which is shown by Doklestić et al. (2014) with a mortality rate of 8.82% and morbidity of 50% in colon perforations. Laparoscopic surgery showed fewer complications and shorter recovery time, reducing infections and pain (Pansa et al., 2020). Mortality rates were 1.6% for LS versus 4.2% for open surgery with lower wound infections ($p < 0.005$). The VAC vs. ROD trial (Rajabaleyan et al., 2022) focused on peritonitis-related complications which is indicating no clear superiority between treatments. Zhong et al. (2023) highlighted LS as safer with fewer complications and

quicker recovery than open surgery. The randomized trial by van Ruler et al. (2007) showed reduced hospital stays and costs in on-demand relaparotomy compared to planned strategies. Studies by Harvitkar et al. (2021) and Hoshino et al. (2021) showed that laparoscopic surgery offers reduced mortality and shorter hospital stays while fewer complications are reported which overall supports its superiority in recovery time.

Laparoscopic surgery for secondary peritonitis due to gastrointestinal perforation generally shows lower mortality and fewer complications with reduced infections was recorded across various studies. Evidences support shorter recovery times and superior outcomes compared to open surgery across various studies. Shahid et al. (2022) retrospective analysis on 158 patients with peritonitis due to gastrointestinal perforation treated in Lahore General Hospital. Surgical interventions include loop ileostomy with postoperative wound infection rates lower when skin wounds were left open and study found low mortality rate (3.2%) while showing efficacy of these interventions. Higher incidences of wound dehiscence were observed compared to other reports and study suggests that leaving skin wounds open post-surgery reduces infection risks.

Doklestić et al. (2014), on the other hand has conducted retrospective study analyzing 204 cases of generalized secondary peritonitis treated at surgical clinic. All patients were treated with laparotomy with early source control, intensive care and antibiotics and results revealed an overall mortality of 8.82% highest in mesenteric ischemia cases (66.67%, $p<0.001p < 0.001p<0.001$). Morbidity was significant (50%) in colon perforations (90%) and study show effectiveness of combined surgical techniques and intensive care in reducing mortality and morbidity. However retrospective and single-center design could limit its generalizability and pose potential bias for overall population. Doklestić et al. (2014) emphasize prompt diagnosis and management to improve clinical outcomes in secondary peritonitis. In another study, which was conducted by Pansa, Kurihara, and Memon in (2020). They designed a systematic review and meta-analysis comparing laparoscopic and open surgery for perforated peptic ulcers (PPUs) where analyzed mortality, complications, and recovery and finding laparoscopy reduced wound infections ($p < 0.005$) and early postoperative pain. Laparoscopy showed higher reoperation rates due to suture site leaks which is attributed to surgeons' experience and steep learning curve. Laparoscopy demonstrates comparable efficacy in selected patients but this technique could be unsuitable for high-risk cases and review emphasizes importance of training and patient selection in enhancing laparoscopic outcomes.

Rajabaleyan et al. (2022) designed randomised controlled trial comparing vacuum-assisted closure (VAC) and relaparotomy on-demand (ROD) for treating secondary peritonitis and they evaluated complications, mortality and quality of life are evaluated during a 30-day to 1-year follow-up period with a projected sample size of 340. Although there isn't enough solid evidence to support either strategy but VAC is thought to minimize problems by 15%. Although it adds variability but its multicenter design improves generalizability. A comprehensive review and meta-analysis comparing laparoscopic surgery (LS) and open surgery (OS) for colonoscopic perforation was carried out by Wu Zhong et al. in 2023. The study which analyzed data from 323 patients, discovered that LS was linked to a faster recovery, fewer problems, and shorter hospital stays and groups' postoperative mortality rates were comparable. The study concludes that LS is a safe and effective alternative to OS for addressing colonoscopic perforations despite the limitations of non-randomized trials and a small sample size.

Oddeke van Ruler et al. (2007) conducted randomized trial comparing on-demand versus planned relaparotomy strategies for severe secondary peritonitis. Among 232 patients on-demand relaparotomy reduced relaparotomies, ICU stays (7 vs. 11 days, $P = .001$), and hospital costs by 23%. Mortality (29% vs. 36%, $P = .22$) and morbidity rates (57% vs. 65%, $P = .25$) were not significantly different and this study supports on-demand relaparotomy as cost-effective and resource-saving without compromising patient outcomes. Nonblinded design and limited generalizability may affect results. Rafique Umer Harvitkar et al. (2021) in their retrospective study, evaluated laparoscopic surgery (LS) in managing perforative peritonitis in 25 patients over five years. Results showed a 90% success rate with mean operative time of 90 minutes, a postoperative stay of 6.9 days and activity resumption in 10–12 days. LS was deemed feasible and safe, with outcomes depending on patient selection and surgeon expertise. Limitations include the small sample size, retrospective design and lack of a control group so results concluded LS is effective for managing selected cases of perforative peritonitis.

Nobuaki Hoshino et al. (2021) conducted nationwide epidemiologic study comparing laparoscopic vs. open surgery for acute diffuse peritonitis due to gastrointestinal perforation while using data from the National Clinical Database from 2016 to 2019. It was demonstrated proportion of laparoscopic surgeries for gastroduodenal perforations increased from 25.2% in 2016 to 30.4% in 2019 and for colorectal perforations, laparoscopic procedures increased from 7.7% in 2016 to 10.5% in 2019. Results show 30-day mortality was similar between the two groups for patients without malignancy but higher in patients with malignancy in both surgery types and laparoscopic surgery group showed reduced estimated blood loss while also lower transfusion requirements and shorter hospital stays. Average length of stay was shorter in laparoscopic group (5.7 days vs. 6.5 days, $p<0.001$) and operating times in the laparoscopic group decreased from 104 minutes in 2016 to 85 minutes in 2019 ($p<0.001$).

CONCLUSION

In conclusion, laparoscopic surgery (LS) is favorable treatment for secondary peritonitis due to gastrointestinal perforation and previous evidences are showing lower mortality and fewer complications, and quicker recovery compared to open surgery. Previous results show reduced wound infections, shorter hospital stays and faster recovery with LS in perforated peptic ulcers and colon perforations. Persisting challenges such as need for skilled surgeons and reoperation rates, and higher costs in multicenter trials are noted. Despite these limitations LS offers significant advantages while improving patient outcomes and reducing healthcare costs when performed by experienced teams.

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