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REVIEW

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Vacuum-assisted closure or primary closure with relaparotomy on-demand in patients with secondary peritonitis: a systematic review and meta-analysis

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Abstract

Background Secondary peritonitis is a serious condition with significant morbidity and mortality. Its management requires emergency laparotomy for source control. Vacuum-assisted closure (VAC) and primary abdominal closure (PAC) are the main strategies for managing the laparostomy after source control. Despite the increasing use of VAC, concerns persist regarding its complications and long-term outcomes compared with PAC.

Methods This systematic review followed PRISMA 2020 and MOOSE. The Cochrane Risk of Bias (RoB 2) tool, MINORS and GRADE framework assessed study quality and evidence certainty. The protocol was registered in PROSPERO (CRD42022304724). A comprehensive search of MEDLINE, Embase, and the Cochrane Library from January 2004 to August 2024 identified studies reporting postoperative outcomes following VAC or PAC after laparotomy for secondary peritonitis. The included studies had to report at least two key outcomes: mortality, postoperative complications, incisional hernia, secondary fascial closure, and hospital or intensive care unit (ICU) length of stay.

Results Thirty-three studies including 4,520 patients were analyzed. Mortality was 31.1% in VAC and 22.2% in PAC ($p=0.327$). Postoperative complications were higher with VAC (71.0% vs. 39.3%, $p=0.001$). Incisional hernia rates were similar (21.3% vs. 20.8%, $p=0.958$). Secondary fascial closure rate was significantly lower with VAC (58.1% vs. 85.9%, $p<0.001$). VAC patients had longer ICU stays (21.1 vs. 9.7 days, $p=0.04$), while hospital stay did not differ. Most studies had a high risk of bias, and GRADE assessment showed low to very low evidence certainty.

Conclusion VAC therapy was associated with more postoperative complications, a lower fascial closure rate, and a longer ICU length of stay compared with PAC. Thirty-day mortality rates did not differ between the approaches. However, most of studies included were subject to serious risk of bias and a low level of certainty in evidence.

Keywords Secondary peritonitis, Vacuum-assisted abdominal closure, Open abdomen

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Background

Secondary peritonitis is a critical and potentially fatal condition resulting from the contamination of the normally sterile peritoneal cavity due to gastrointestinal perforation or intra-abdominal organ injury [1]. Its underlying causes include inflammatory pathologies, malignancies, trauma, postoperative complications, and spontaneous perforations [2, 3]. Without timely source

control, it can rapidly escalate to sepsis, multi-organ failure, abdominal compartment syndrome, and death [4]. Intra-abdominal sepsis constitutes the second leading cause of sepsis-related mortality in critically ill patients [5]. The 28-day mortality rate in cases of complicated intra-abdominal infections can range from 19.1 to 29.1% [6, 7]. However, in patients with severe sepsis or septic shock, mortality can rise up to 67.8% [3, 7].

The latest guidelines recommend early initiation of broad-spectrum antibiotics, timely and adequate surgical source control, and hemodynamic support, including goal-oriented fluid resuscitation and vasopressor use in cases of septic shock, emphasizing goal directed antimicrobial treatment based on the infection's severity and patient comorbidities [8–13]. Patients with secondary peritonitis may require multiple surgical interventions, particularly in cases of persistent infection or postoperative complications [14–17]. The management of the laparostomy after source control involves either primary abdominal closure (PAC) or vacuum-assisted closure (VAC), which are the two most frequently used techniques [4, 8–13]. VAC may be preferable in physiologically unstable patients with ongoing sepsis or when primary closure is unsafe, as it facilitates subsequent exploration, enhances source control, and mitigates intra-abdominal hypertension, potentially preventing abdominal compartment syndrome [4, 8–13]. While VAC facilitates intra-abdominal pressure management, its role in preventing abdominal compartment syndrome remains debated, as intra-abdominal hypertension is a multifactorial condition requiring comprehensive management beyond negative pressure therapy [18, 19]. PAC is preferred when feasible, as it restores abdominal integrity and reduces the need for further interventions but may not be viable in patients with bowel edema, severe peritonitis, or intra-abdominal hypertension [4, 8–13].

VAC has been associated with complications such as delayed abdominal closure, enteroatmospheric fistula (EAF), prolonged hospitalization, non-physiologic catabolic drainage and ventral hernia formation [4, 8–13]. Recent studies have reported conflicting findings regarding the direct role of VAC in EAF development, with evidence suggesting that EAF formation is more strongly correlated with the severity of the underlying peritoneal pathology rather than the choice of closure method [20, 21]. Given these risks, the decision to maintain an open abdomen should be carefully weighed against the benefits.

Few comparative retrospective studies have reported varying mortality outcomes for patients with secondary peritonitis treated with VAC compared with PAC [22–24]. Some cohort studies indicate higher in-hospital mortality in patients treated with VAC due to their initial more critical condition [22]. In contrast, others suggest a lower mortality rate in patients treated with VAC who present with severe sepsis or septic shock [23]. A recent retrospective comparative study further contributes to this discussion by showing no significant differences in postoperative mortality between VAC and PAC at 30 days, 90 days, and 1 year [24]. The discrepancy in survival outcomes is likely due to differences in patient conditions and disease severity [22–24].

A 2015 systematic review on negative pressure wound therapy (NPWT) techniques in non-trauma patients with secondary peritonitis reported mortality rates of 21.5–30.5% and EAF rates of 5.7–14.7%, varying by technique [25]. The lowest mortality, EAF and highest fascial closure rates were observed when mesh-mediated fascial traction was combined with VAC, supporting current recommendations for mesh-mediated fascial traction as the preferred approach.

To our knowledge, no systematic review has specifically compared outcomes between VAC and PAC for secondary peritonitis. This systematic review aims to synthesize current evidence comparing VAC and PAC with relaparotomy on demand (ROD) in patients with secondary peritonitis.

Methods

This study was conducted according to the Preferred Reporting Items for Systematic Reviews and meta-analyses (PRISMA) 2020 guidelines and Meta-analysis of Observational Studies in Epidemiology (MOOSE) checklist (Supplementary material 1 and 2) [26, 27]. The protocol was registered in PROSPERO (CRD42022304724). The research question was structured using the PICOS framework, which is detailed in (Supplementary Material 3). The population (P) included adult patients undergoing surgical management for secondary peritonitis. The intervention (I) was VAC therapy, compared with conventional management using PAC in combination with ROD (C). The primary outcome (O) was 30-day and overall mortality, while secondary outcomes included overall postoperative complications, EAF development, fascial closure rates, incisional hernia rates, intra-abdominal abscess formation, Acute Physiology and Chronic Health Evaluation II (APACHE II) scores, hospital and Intensive Care Unit (ICU) length of stay, and VAC treatment details (duration and number of dressing changes). The study design (S) encompassed prospective and retrospective cohort studies, case–control studies, and randomized controlled trials (RCTs).

Literature search

A systematic literature search was conducted in collaboration with a medical research librarian from the University of Southern Denmark to ensure methodological precision. The search was performed in Embase, MEDLINE (via Ovid), and the Cochrane Central Register of Controlled Trials (CENTRAL), using both controlled vocabulary (MeSH and Emtree) and free-text terms. It targeted studies investigating negative pressure wound therapy (NPWT), open abdomen techniques, and relaparotomy on-demand in the context of secondary peritonitis and intra-abdominal infections. The complete search strategy, including Boolean operators, truncation, and field-specific terms, is provided in (Supplementary Material 4). The search was limited to studies published between 1 January 2004 and 1 August 2024.

Two independent reviewers (PR and PC) conducted the initial screening and selection of studies. In cases of disagreement, a third author (MBE) was consulted to reach a consensus. All retrieved studies were imported into Covidence® (Covidence, Veritas Health Innovation, Melbourne, Australia) for the screening process and data extraction.

To ensure comprehensive coverage, a manual search for additional relevant studies was performed by reviewing the reference lists of the included studies. For studies not readily accessible through the databases, an additional effort was made to obtain them by directly contacting the authors. This only occurred in one case, which resulted in obtaining the article.

Study selection

Studies were eligible for inclusion if they described the use of any type of VAC or PAC with ROD in patients with secondary peritonitis. Studies involving patients with mixed aetiologies were included if ≥ 50% of the cohort had secondary peritonitis or if data specifically related to patients with peritonitis could be extracted separately. The ≥ 50% peritonitis threshold was chosen to ensure the included studies maintained clinical relevance while allowing for a sufficiently large dataset. Only original full-text studies written in English, including randomised controlled trials (RCTs), cohort, and observational studies, were considered for inclusion. Given the rarity of RCTs in this domain, observational studies were included to provide a more comprehensive assessment of clinical outcomes.

The exclusion criteria were review studies, opinion papers, case reports involving fewer than five patients, paediatric series, studies with non-midline incisions, animal and laboratory studies, and studies where the results for patients with secondary peritonitis were not reported separately. To be eligible for inclusion, an article had to provide information on the VAC technique applied and to report at least two of the following outcomes: 30 day and overall mortality, overall postoperative complications, EAF, fascial closure, incisional hernia, intra-abdominal abscess, hospital and ICU length of stay, and VAC treatment (duration and the number of changes). In cases where studies presented separate patient subgroups based on different underlying conditions, each subgroup was evaluated independently, provided they met the inclusion criteria. Studies focusing on primary closure with planned relaparotomy, primary peritonitis, peritonitis following abdominal trauma, or utilising the damage control principle were excluded. Unpublished and grey literature were excluded to ensure methodological precision and consistency in data reporting. Peer-reviewed studies were prioritized to minimize the risk of incomplete or non-standardized data presentation, aligning with established systematic review methodologies in the field.

Data extraction

Following study selection, two independent reviewers extracted data (PR and PC). Discrepancies were resolved through discussion or consultation with a third reviewer (MBE). No automation tools were used in the extraction process.

Data were systematically extracted according to the predefined outcome measures. The extracted data included study characteristics (first author, year of publication, inclusion period, study design) and patient characteristics (number of subjects, underlying etiology, and indications for VAC or PAC with ROD). Disease severity metrics, including the APACHE II score and Mannheim Peritonitis Index (MPI), were systematically recorded. Additionally, details on the specific VAC technique applied were collected.

Postoperative outcomes included 30-day and overall mortality rates, postoperative complications, EAF occurrence, fascial closure rate, postoperative intra-abdominal abscess formation, and incisional hernia rates. Data on hospital and ICU length of stay, VAC treatment duration, and the number of dressing changes were also extracted.

Methodological quality assessment

Study quality was independently assessed by two reviewers using the Cochrane Risk of Bias (RoB 2) tool for randomized controlled trials and the Methodological Index for Non-Randomized Studies (MINORS) for observational studies. Discrepancies were resolved through discussion or consultation with a third reviewer [28, 29]. The certainty of evidence was assessed using the Grading of Recommendations Assessment, Development,

and Evaluation (GRADE) approach [30]. A summary of findings table was created for key clinical outcomes using GRADEpro GDT software (GRADEpro GDT: GRADEpro Guideline Development Tool, McMaster University, 2020, developed by Evidence Prime, Inc., available at https://gradepro.org).

Selective outcome reporting bias was considered by comparing reported outcomes with study protocols where available. Funnel plots and Egger's test were used to assess potential publication bias.

Statistical analysis

Meta-estimates for each intervention were calculated using common- and random-effects models, with random-effects estimates reported when heterogeneity was significant ($I^2 > 50$) [31]. Otherwise, common-effects estimates are presented. Effect measures included risk ratios for binary outcomes and mean differences for continuous variables.

Heterogeneity across studies was assessed using Cochran's Q test and quantified using the I^2 statistic. A sensitivity analysis was conducted including only comparative studies from the meta-analysis that reported one or more outcomes. Publication bias was assessed using Egger's test and by inspection of asymmetry in funnel plots indicating heterogeneity.

All statistical analyses were performed using Stata® statistical software (version 18.0; StataCorp LP, College Station, Texas, USA) or R 4.3.2 (The R Foundation for Statistical Computing, Vienna, Austria). A p-value < 0.05 was considered statistically significant.

Results

Systematic review

A total of 2583 references were imported for screening, with 701 duplicates identified and removed. The remaining 1882 studies were reviewed by title and abstract and 173 were selected for full-text screening. Of these, 140 studies were excluded, leaving 33 studies that met the inclusion criteria (Table 1 and Fig. 1).

Study characteristics

In total 4520 patients were included across all studies. Of these, 2059 patients (45.5%) were treated with VAC, while 2461 patients (54.5%) were treated with PAC. The majority of the included studies were observational in design (22 retrospective and 9 prospective studies). There were two RCTs among the included studies, but neither directly compared both techniques; data from the PAC group were extracted separately from these studies. Table 1 shows an overview of the included studies.

Risk of bias assessment

Considering the two RCTs, the study by Robledo et al. [32] study showed a high risk of bias in randomisation and deviations from intended interventions, while outcome measurement and missing outcome data had a low risk. Some concerns regarding the reported results led to an overall high risk of bias. The study by Van Ruler et al. [33] had a low risk of bias in randomisation, deviations from intended interventions, missing outcome data, and outcome measurement. However, concerns about reported results resulted in an overall assessment of "some concerns". A figure depicting the risk-of-bias assessment for the RCTs is provided in the (Supplementary material 5).

The assessment of the observational studies indicated a generally high risk of bias, particularly in relation to confounding factors and participant selection. The observational nature of the majority of the included studies contributed to an increased risk of selection bias and performance bias. Additionally, the lack of blinding in many of the included studies further increased the risk of bias in the outcome measurements. The (Supplementary material 6) include a detailed schematic table summarizing the risk-of-bias evaluation for the included observational studies.

GRADE assessment and publication bias

The quality of evidence for key clinical outcomes was assessed using the GRADE approach, based on the predefined primary and secondary outcomes. The certainty of evidence was predominantly low to very low, largely due to high risk of bias, serious inconsistencies in reporting, heterogeneity in patient selection and treatment protocols, and imprecision in effect estimates. Some outcomes, such as postoperative complications, EAF, and VAC treatment details, had very serious concerns regarding bias and inconsistency, further limiting interpretability. Full details of the GRADE quality assessment are provided in (Supplementary Material 7).

Publication bias was assessed using Egger's test and visual inspection of funnel plots. Statistically significant small-study effects were detected for 30-day mortality (PAC), postoperative complications (VAC), EAF (VAC), and hospital length of stay (VAC). Visual asymmetry without significant Egger's test results was noted in other outcomes, including 30-day mortality (VAC), postoperative complications (PAC), and incisional hernia (VAC). Secondary fascial closure (PAC), VAC treatment duration, and VAC dressing changes showed lower risk of bias. Full results are presented in (Table 2 and Supplementary Files 9–30).

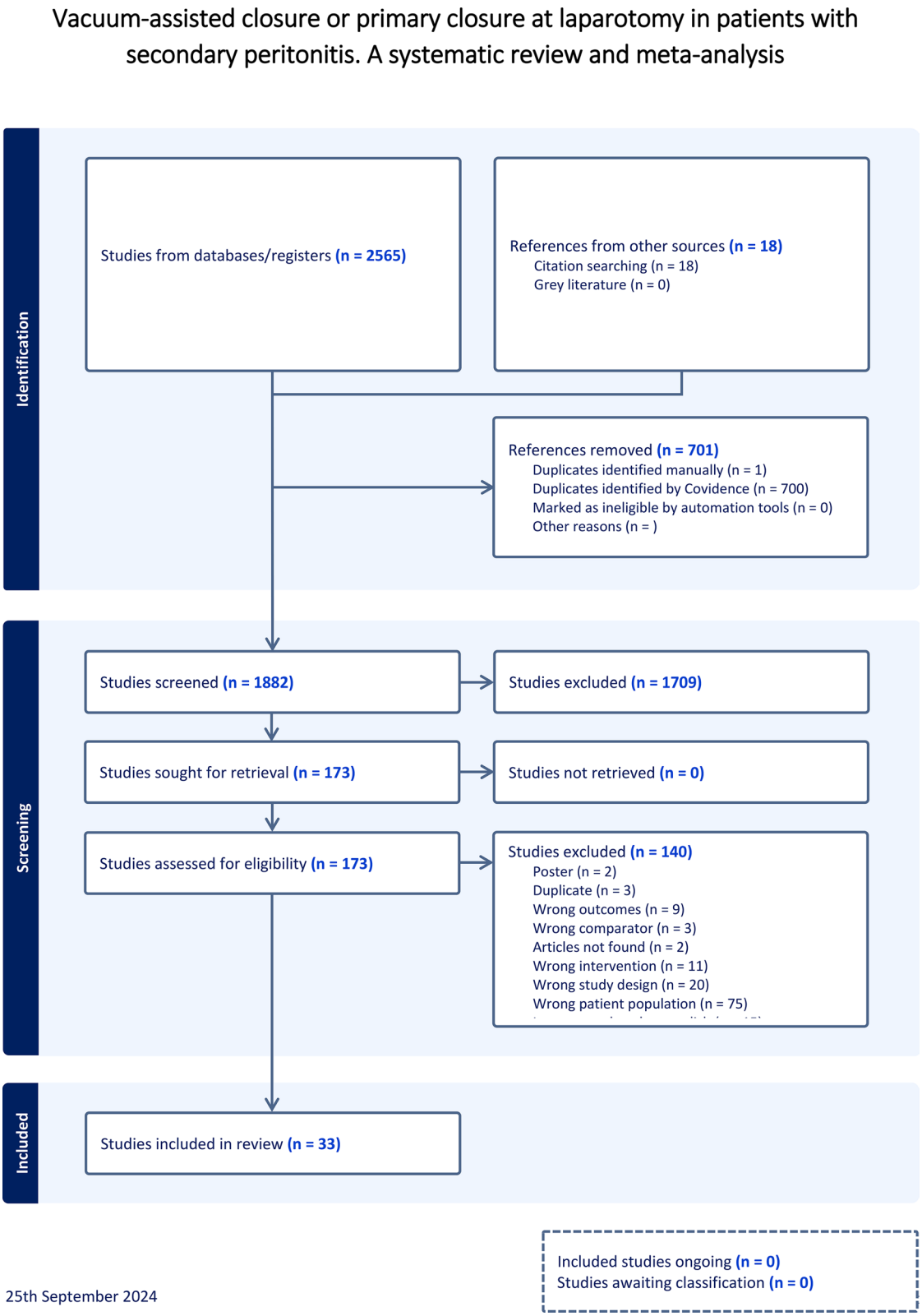

Fig. 1 PRISMA flow diagram. Flowchart illustrating the process of study identification, screening, eligibility assessment, and inclusion according to the PRISMA 2020 guidelines

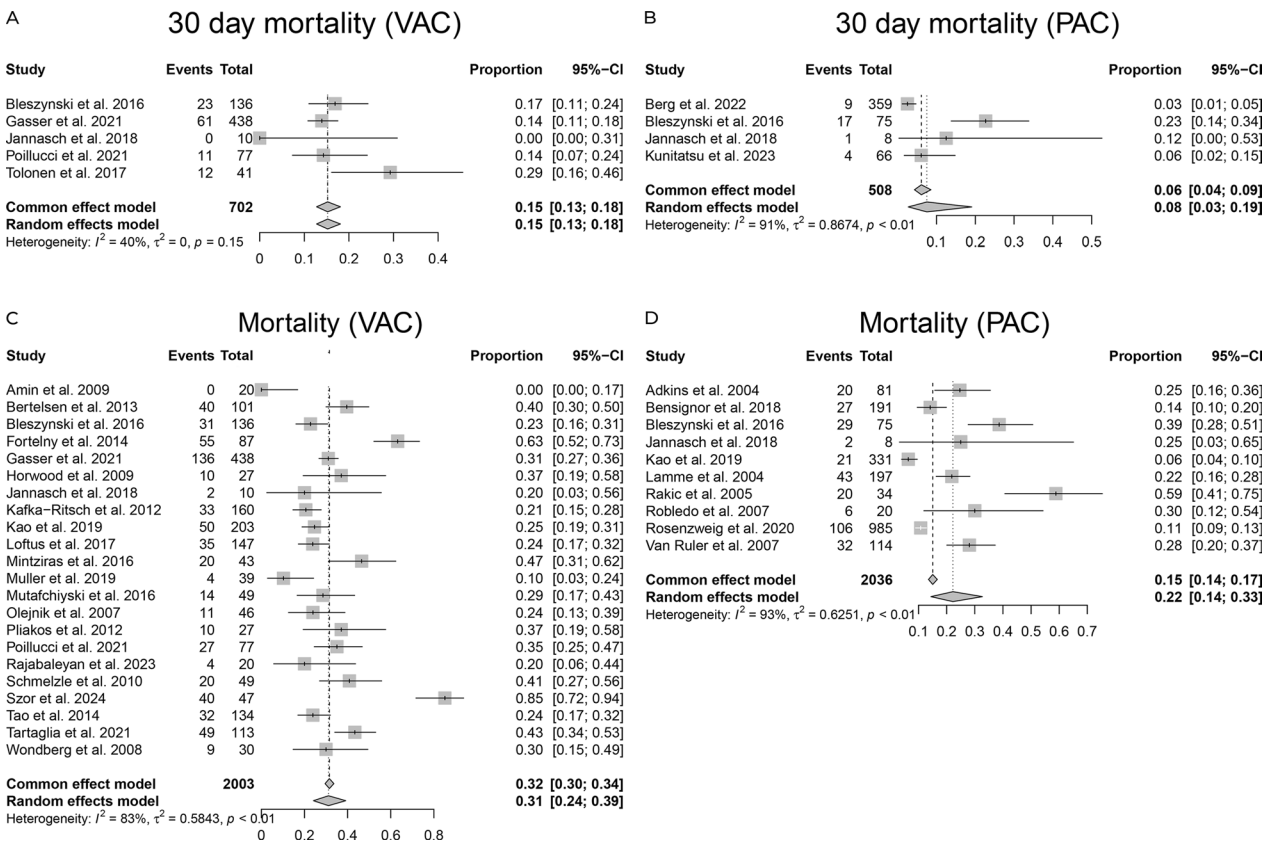

Fig. 2 Forest plots of 30-day and overall mortality. **A** Forest plot of 30-day mortality in patients treated with vacuum-assisted closure (VAC). **B** Forest plot of 30-day mortality in patients treated with primary abdominal closure (PAC). **C** Forest plot of overall mortality in the VAC group. **D** Forest plot of overall mortality in the PAC group

Patient demographics

The key demographic outcomes, age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, the MPI, and the Charlson Comorbidity Index (CCI), were reported inconsistently and in only a limited number of studies. Consequently, only age and sex variations for each study are summarised in (Table 1), and therefore, no meta-analysis was conducted on demographic data due to insufficient and heterogeneous reporting.

Meta-analysis

The results of the meta-analysis is summarized in (Table 2). The following studies were included in the meta-analysis: for VAC, data were extracted from [22, 23, 34–55], while PAC was analyzed using data from [22, 23, 32, 33, 35, 56–62]. These studies contributed to pooled estimates for all predefined outcomes. (Figs. 2, 3, 4, 5, 6, 7) illustrate the forest plots for 30-day mortality, overall mortality, postoperative complications, EAF, fascial closure rates, incisional hernia rates, intra-abdominal abscess formation, APACHE II scores, hospital and ICU length of stay, VAC treatment duration, and the number of dressing changes.

Mortality rate

Five studies, with 702 patients, assessed 30-day mortality in the VAC group [23, 34–37], revealing an average mortality rate of 15.2% (95% [CI] 12.7–18.1%). In the PAC group, 4 studies with 508 patients reported a 30-day mortality rate of 7.5% (95% CI 2.7–19%) [23, 35, 56, 57]. The difference between the groups was not significant ($p = 0.08$). Heterogeneity for the VAC group was low ($I^2 = 40.4\%$, $p = 0.1517$), while there was high heterogeneity for the PAC group ($I^2 = 90.7\%$, $p < 0.0001$).

Overall mortality analysis was reported in 22 VAC studies including 2003 patients [22, 23, 34–36, 38–54] and 10 PAC studies with 2036 patients [22, 23, 32, 33, 35, 58–62]. The average mortality rate was 31.1% (95% CI 24.1–39.1%) in the VAC group and 22.2% (95% CI 14–32%) in the PAC group ($p = 0.3$). Heterogeneity was high in both groups, with $I^2 = 83.3\%$ for VAC and $I^2 = 92.7\%$ for PAC ($p < 0.0001$ for both).

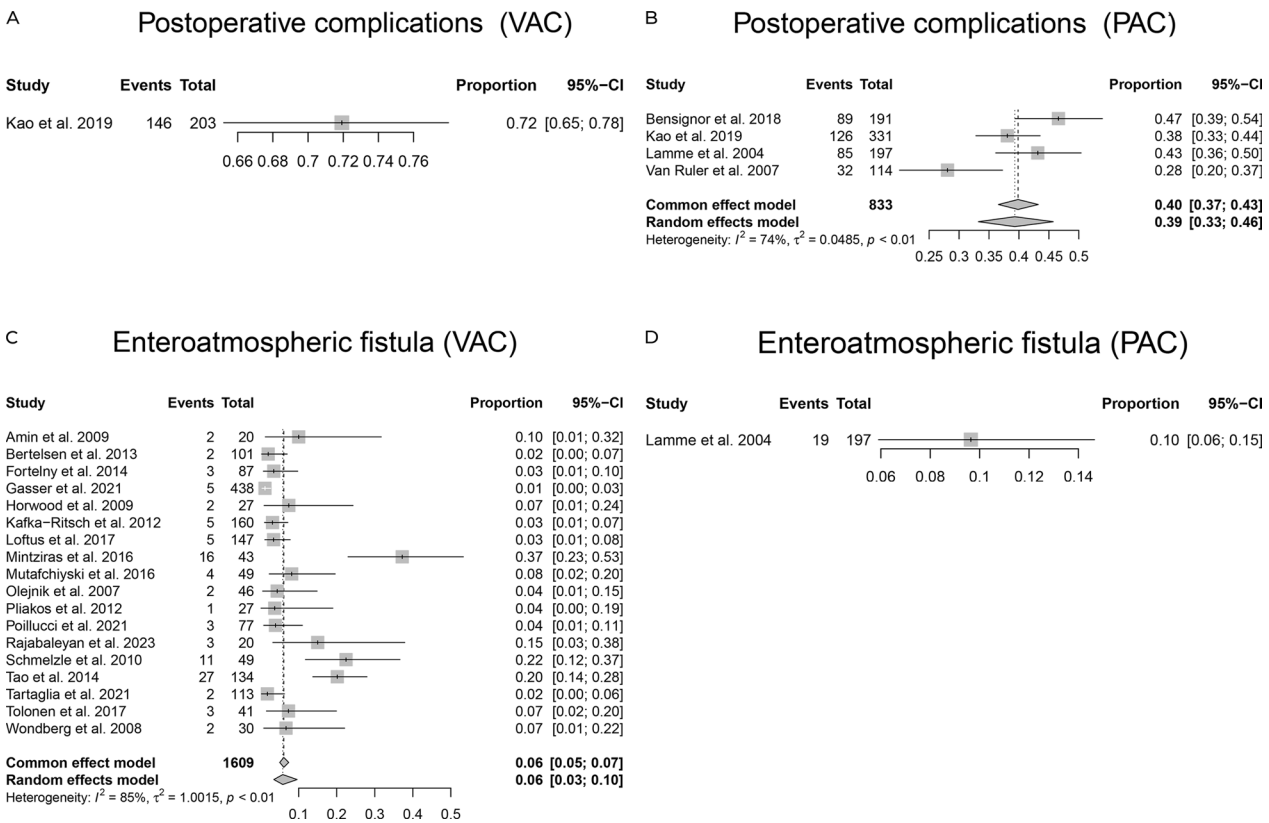

Fig. 3 Forest plots of postoperative complications and enteroatmospheric fistula (EAF). **A** Forest plot of postoperative complications in the VAC group. **B** Forest plot of postoperative complications in the PAC group. **C** Forest plot of the incidence of EAF in the VAC group. **D** Forest plot of the incidence of EAF in the PAC group

Postoperative complication rate

Postoperative complications were reported in 1 VAC study with 203 patients; the rate was 71% (95% CI 65–77%) [22]. In the PAC group including 4 studies and 833 patients, the rate was 39.3% (95% CI 33.2–45.7%) [22, 33, 59, 60]. The difference was statistically significant ($p=0.001$). Heterogeneity was high for the PAC group $I^2=73.6\%$ ($p<0.009$).

Enteroatmospheric fistula rate

The incidence of EAF was reported in 18 studies involving 1609 patients treated with VAC, with a rate of 5.8% (95% CI 3.4–9.5%) [34, 36–44, 46–50, 52–54]. In comparison, 1 study including 197 patients treated with PAC reported an EAF rate of 9.6% (95% CI 6.2–14.6%) [60]. The difference between the VAC and PAC groups was not significant ($p=0.157$). Heterogeneity was high in the VAC group ($I^2=84.9\%$, $p<0.0001$).

Fascial closure rate

For VAC, 19 studies including 1644 patients reported a secondary completed fascial closure rate of 58.1% (95% CI 44.4–70.6%) [34, 36–46, 48, 50–55]. This was significantly lower than the primary closure rate of 85.9% (95% CI 78.3–91.2%) reported in a single PAC study with 113 patients ($p<0.001$) [33]. Heterogeneity was high for the VAC group ($I^2=75.2\%$, $p=0.0005$).

Incisional hernia rate

For the VAC group, data regarding incisional hernias was reported in 4 studies including 617 patients, with a pooled rate of 21.3% (95% CI 8.4–44.3%) [34, 36, 40, 55]. For PAC, 1 study reported an incisional hernia rate of 20.8% (95% CI 15.7–27%, 41 cases among 197 patients) [60]. Heterogeneity in the VAC group was high ($I^2=92.7\%$, $p<0.0001$).

Intra-abdominal abscess rate

Regarding VAC, 4 studies with 363 patients reported an abscess rate of 13.9% (95% CI 8.2–22.4%) [42, 46, 49, 52], while for PAC, 3 studies including 297 patients reported a rate of 12.7% (95% CI 6.5–23.2%) [57, 60, 61]. The difference between the groups was not significant ($p=0.832$). Heterogeneity was high for both groups, with $I^2=77.7\%$

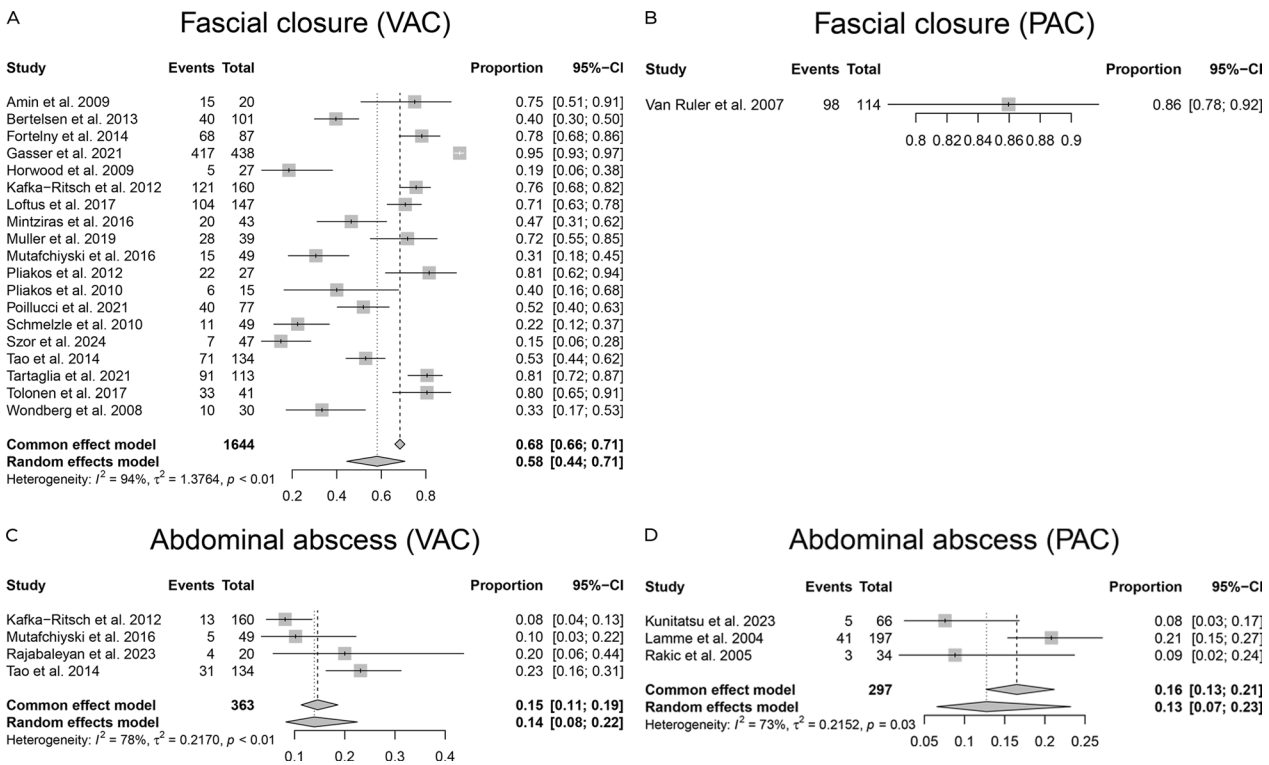

Fig. 4 Forest plots of fascial closure and incisional hernia. **A** Forest plot of fascial closure rates in the VAC group. **B** Forest plot of fascial closure rates in the PAC group. **C** Forest plot of incisional hernia incidence in the VAC group. **D** Forest plot of incisional hernia incidence in the PAC group

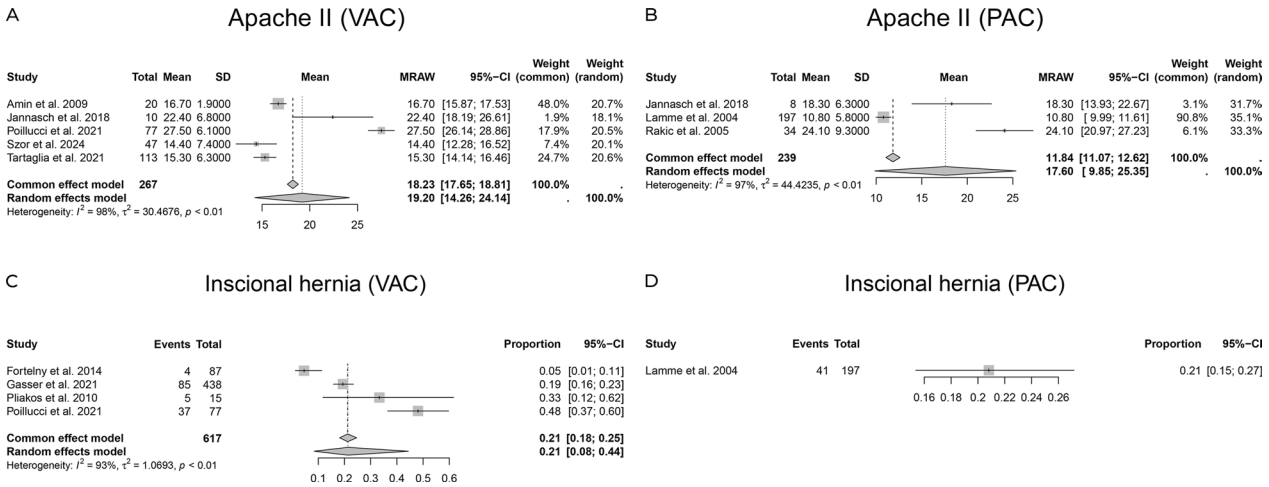

Fig. 5 Forest plots of abdominal abscess and APACHE II scores. **A** Forest plot of abdominal abscess rates in the VAC group. **B** Forest plot of abdominal abscess rates in the PAC group. **C** Forest plot of APACHE II scores in the VAC group. **D** Forest plot of APACHE II scores in the PAC group

for VAC and I^2 = 72.8% for PAC (p = 0.0038, and p = 0.02 respectively).

APACHE II score

For VAC, 5 studies reported an average APACHE II score of 19.19 (95% CI 14.25–24.13) [35, 36, 38, 51, 53], while for PAC, 3 studies indicated an average score of 17.60 (95% CI 9.85–25.35) [35, 60, 61]. The difference between the groups was not significant (p = 0.739). Heterogeneity was notably high, with I^2 = 98.3% for the VAC group and I^2 = 97.3% for the PAC group (p < 0.0001 for both groups).

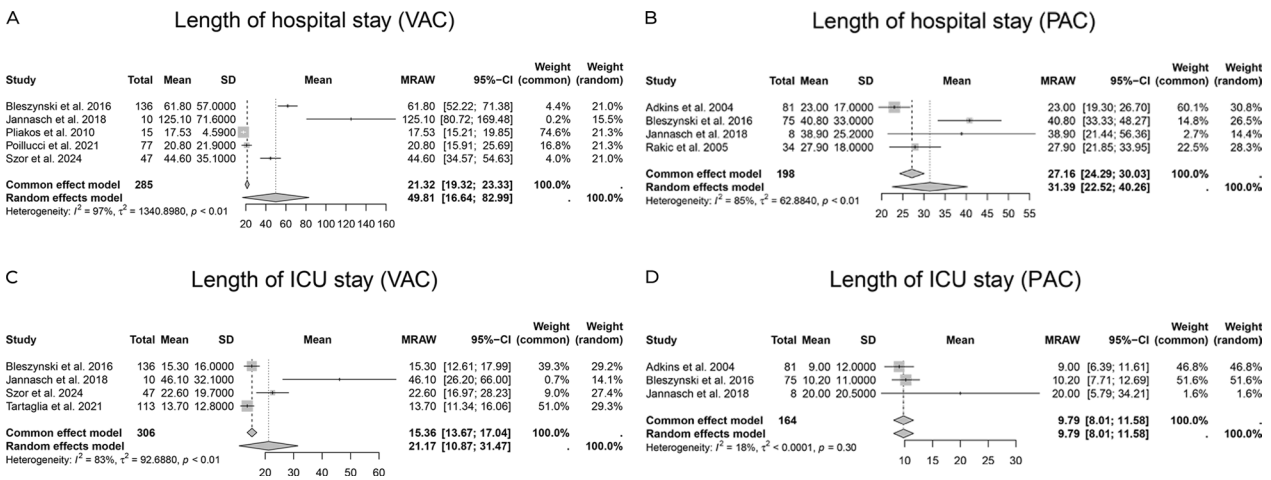

Fig. 6 Forest plots of length of hospital and ICU stay. **A** Forest plot of hospital length of stay in the VAC group. **B** Forest plot of hospital length of stay in the PAC group. **C** Forest plot of ICU length of stay in the VAC group. **D** Forest plot of ICU length of stay in the PAC group

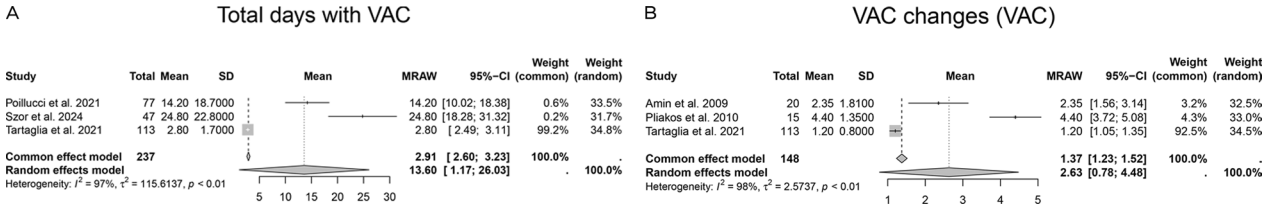

Fig. 7 Forest plots of VAC-specific outcomes. **A** Forest plot illustrating the total number of days with VAC therapy. **B** Forest plot illustrating the number of VAC system changes performed per patient

Hospital and ICU length of stay

Five VAC studies reported an average hospital stay of 49.8 (95% CI 16.6–82.9) days [23, 35, 36, 51, 55], while four PAC studies showed an average of 31.3 (95% CI 22.5–40.2) days ($p=0.303$) [23, 35, 58, 61]. Heterogeneity was high in both groups ($I^2=96.7\%$ for VAC and $I^2=84.6\%$ for PAC, $p<0.0001$).

Four VAC group reported an average ICU stay of 21.1 (95% CI 10.8–31.4) days [23, 35, 51, 53], which was significantly longer compared with what was reported in 3 PAC studies (9.7, 95% CI 8.0–11.5 days, $p=0.037$) [23, 35, 58]. Heterogeneity was high in the VAC group ($I^2=82.8\%$, $p=0.0006$), while the PAC group showed low heterogeneity ($I^2=18\%$, $p=0.2953$).

VAC treatment duration and number of dressing changes

Three VAC studies reported an average treatment duration of 13.6 (95% CI 1.1–26) days [36, 51, 53]. Heterogeneity was high ($I^2=97.2\%$, $p<0.0001$). Three VAC studies reported an average of 2.6 (95% CI 0.7–4.4) changes [38, 53, 55]. Heterogeneity was very high ($I^2=97.7\%$, $p<0.0001$).

Sensitivity analysis

In a sensitivity analysis of the comparative studies (n = 2–3 per outcome) included in the main meta-analysis (Supplementary material 8) [22, 23, 35], no significant difference was observed in 30-day mortality based on two studies (RR = 0.7130, 95% CI 0.4117–1.2346, $p=0.2272$; $I^2=0\%$). Overall mortality, based on three studies, also did not differ significantly between groups (RR = 1.2983, 95% CI 0.3594–4.6897, $p=0.6903$), although substantial heterogeneity was present ($I^2=94.1\%$). Two studies reported on hospital stay, with a mean difference of 49.4 days in favor of the PAC group (95% CI −14.0 to 112.7, $p=0.1268$; $I^2=85.2\%$), but this was not statistically significant. ICU stay was significantly prolonged in the VAC group, with a mean difference of 5.6 days (95% CI 1.9–9.2, $p=0.0026$; $I^2=63.9\%$).

Discussion

This systematic review and meta-analysis compared VAC and PAC outcomes in patients with secondary peritonitis. While there were no significant differences between VAC and PAC in mortality,EAF incidence, incisional hernia rate, or intra-abdominal abscess formation, PAC was associated with a significantly lower postoperative

Table 1 Summarizes key characteristics of studies on the use of VAC and PAC

Author	Year of Publication	Study Period	Study Design	N Total VAC	N Total PAC	Peritonitis Etiology (n)	Origin of Infection (Upper and Lower GI) (%)	Treatment Strategy	VAC Technique	Age VAC	Age PAC	Females VAC	Females PAC
Adkins et al. [58]	2004	1998–2002	Retrospective	–	81	Gastric 16(20%) Small intestine 9(11%) Colon 55(69%)	Upper 20% Lower 80%	Primary closure	–		69 (13)		49 (60%)
Amin et al. [38]	2009	2005–2008	Prospective	20	–	Perforated stomach and duodenum 4(20%) Small bowel perforation 4(20%) Fecal peritonitis 9(45%) Pelvic sepsis 3(15%)	Upper 20% Lower 80%	VAC	VAC® Abdominal Dressing System (KCl, San Antonio, Texas, USA)	59.3 (3.95)		9 (45%)	
Bensignor et al. [59]	2018	2004–2013	Retrospective	–	191	Anastomotic leakage 127(47%) Duodenal fistula 16(8%) Perforation 40(21%) Enteral necrosis 11(6%) Colonic necrosis 12(6%) Abscess 10(5%) Secondary leakage of stump left in the abdomen 6(3%) No etiology found 5(3%) Biliary fistula 2(1%)	N/A	Primary closure	–		61		94 (49%)
Berg et al. [56]	2022	2014–2016	Retrospective	–	359	Colonic perforation 359(100%)	Lower 100%	Primary closure	–		64 (55.8–73)		189 (53%)
Bertelsen et al. [39]	2013	2007–2011	Retrospective	101	–	Lower gastrointestinal tract with peritonitis 101(100%)	Lower 100%	VAC	VAC® Abdominal Dressing System (KCl, San Antonio, Texas, USA)	66.8 (61.4–74.2)		57 (56%)	
Bleszynski et al. [23]	2016	2006–2010	Retrospective	136	75	Large bowel perforation 33(15.6%) Small bowel perforation 31(14.7%) Ischemia/Infarct 31(14.7%) Anastomotic failure 30(14.2%) Clostridium difficile colitis 14(6.6%) Abscess 13(6.2%) Necrotizing pancreatitis 9(4.3%) Gastric perforation 7(3.3%) Biliary complication 6(2.8%) Abdominal wall infection 6(2.8%) Large bowel obstruction 4(1.9%) Fistula 3(1.4%) Typhlitis 2(0.9%) Miscellaneous 13(6.2%)	N/A	VAC and primary closure	N/A	61 (14)	67 (16)	70 (51%)	40 (53%)
Fortelny et al. [40]	2014	2007–2012	Prospective	87	–	Upper GI (stomach,duodenum,smallbowel) 29.9% Lower GI (large bowel, rectum) 58.6% Other/peritonitis 11.5%	N/A	VAC with dynamic sutures	VAC® Abdominal Dressing System (KCl, San Antonio, Texas, USA)	69 (25.2–92.9)		39 (45%)	

Table 1 (continued)

Author	Year of Publication	Study Period	Study Design	N Total VAC	N Total PAC	Peritonitis Etiology (n)	Origin of Infection (Upper and Lower GI) (%)	Treatment Strategy	VAC Technique	Age VAC	Age PAC	Females VAC	Females PAC
Gasser et al. [34]	2021	2008–2018	Retrospective	438	–	Primary bowel perforation 163(37%) Anastomotic leakage 53(12%) Intestinal ischemia 53(12%) Ileus 53(12%) Postoperative bowel perforation 32(7%) Abdominal compartment 15(3%) Gastric perforation 13(3%) Pancreatic fistula 13(3%) Secondary peritonitis 11(3%) Burst abdomen 9(2%) Biliary leakage 8(2%) Other 15(3%)	Upper 8% Lower 84% Other 8%	VAC with dynamic sutures	VAC® Abdominal Dressing System (KCI, San Antonio, Texas, USA)	66 (12–94)		194 (44%)	
Horwood et al. [41]	2009	2003–2008	Prospective	27	–	Perforated diverticular disease 8(29,7%) Perforated sigmoid carcinoma 1(3,7%) Bowel anastomotic leaks 6(22,2%) Necrotizing pancreatitis 1(3,7%) Small bowel perforation 6(22,2%) Abdominal compartment syndrome following emergency splenectomy 1(3,7%) Perforated appendicitis 1(3,7%) Biliary peritonitis following cholodochoduodenal, anastomosis 1(3,7%) Large pyosalpinx 1(3,7%) Ischemic colon secondary to C. difficile infection 1(3,7%)	Upper 7,5% Lower 85% Other 7,5%	VAC	TRAC–VAC® system	73 (34–84)		14 (52%)	
Jannasch et al. [35]	2018	N/A	Prospective	10	8	Anastomotic leakage 9(50%) Isolated perforation of the intestine 4(22,2%) Mesenteric ischemia 2(11,1%) Intestinal fistula 1(5,6%) Infected tumor necrosis 1(5,6%) Infected hematoma 1(5,6%)	Lower 100%	VAC and primary closure	VAC® Abdominal Dressing System (KCI, San Antonio, Texas, USA)	66 (7.8)	64.8 (13.2)	4 (50%)	5 (50%)
Kafka-Ritsch et al. [42]	2012	2005–2010	Retrospective	160	–	Sepsis from an intraabdominal infection in 125(78%) Intestinal ischemia in 26(16%) Other in 10(6%) (abdominal compartment syndrome, trauma) Other peritonitis 19(12%)	Small bowel/stomach 23(14%) Colon/rectum 106(66%) Pancreas 12(8%) Others/peritonitis 19(12%)	VAC with dynamic sutures	VAC® Abdominal Dressing System (KCI, San Antonio, Texas, USA)	66 (21–88)		58 (36%)	

Table 1 (continued)

Author	Year of Publication	Study Period	Study Design	N Total VAC	N Total PAC	Peritonitis Etiology (n)	Origin of Infection (Upper and Lower GI) (%)	Treatment Strategy	VAC Technique	Age VAC	Age PAC	Females VAC	Females PAC
Kao et al. [22]	2019	2012–2016	Retrospective	203	331	Perforated gastrodoudenal ulcer Sigmoid volvolous Non-traumatic perforation of bowel Colon or ileum Intestinal ischemia Perforated diverticulitis Perforated appendicitis with generalized peritonitis Perforation 154 (29%) Contamination 38 (7%) 105 (20%) Obstruction 218(41%) Other 19(4%)	N/A	VAC and primary closure	VAC® Abdominal Dressing System (KCI, San Antonio, Texas, USA)	63 (54–72)	59 (47–70)	109 (54%)	179 (54%)
Kunitatsu et al. [57]	2023	2013–2019	Retrospective	–	66	Colorectal perforations 66(100%)	100% lower	Primary closure	–		75 (68–85)		35 (53%)
Lamme et al. [60]	2004	1994–2000	Retrospective	–	197	Perforation 85 (43.1%) Anastomotic leakage 50 (25.4%) Ischemia 6 (3%) Pancreatitis 10 (5.1%) Bile leakage 16 (8.1%) Abscess 17 (8.6%) Other 13 (6.6%)	Upper 49 (25%) Lower 124(63%) Other 24(12%)	Primary closure	–		56.2 (16)		84 (43%)
Loftus et al. [43]	2017	2011–2015	Retrospective	147	–	Bowel ischemia 74(50%) Hollow viscus perforation 50 (34%) Inflammation/infection with perforation 20 (14%) Anastomotic leak 3 (2%)	N/A	VAC	VAC® Abdominal Dressing System (KCI, San Antonio, Texas, USA)	61 (53–72)		72 (49%)	
Mintziras et al. 44]	2016	2005–2014	Retrospective	43	–	Anastomotic leakage 20 (46.5%) Perforation 17 (39.5%) Intestinal ischemia 4 (9%) Necrotizing pancreatitis 2 (5%)	N/A	VAC	Absorbable Vicryl mesh and a polyurethane (PU) VAC foam connected to a negative pressure system	65 (24–90)		24 (56%)	
Muller et al. [45]	2019	2015–2016	Prospective	39	–	Perforation stomach 4(10%) Perforation small bowel 8(21%) Anastomotic leak small bowel 1(3%) Perforation colon/rectum 20(51%) Anastomotic leak colon/rectum 4(10%) Other 1(3%)	Upper 4 (10%) Lower 33(87%) Other 1(3%)	VAC	SuprasorbVR CNP, Lohmann & Rauscher GmbH & Co. KG, Rengsdorf, Germany	57 (17–89)		11 (28%)	
Mutafchiyski et al. [46]	2016	2006–2013	Prospective	49	–	Upper GI perforation 4(8%) Small bowel perforation 7(14%) Colonic perforation 38 (78%)	Upper 4(8%) Lower 45(92%)	VAC	VAC® Abdominal Dressing System (KCI, San Antonio, Texas, USA)	58 ()		16 (33%)	

Table 1 (continued)

Author	Year of Publication	Study Period	Study Design	N Total VAC	N Total PAC	Peritonitis Etiology (n)	Origin of Infection (Upper and Lower GI) (%)	Treatment Strategy	VAC Technique	Age VAC	Age PAC	Females VAC	Females PAC
Olejnik et al. [47]	2007	2002–2006	Retrospective	46	–	Hemorrhagic-necrotic pancreatitis 18(39%) Surgery and endoscopy complications 10(22%) Anastomotic leak 6(13%) Intractable small bowel perforation 1(2%) Retroperitoneal phlegmona 6(13%) Subphrenic/perihepatal abscess 4(9%) Peritonitis from postpartum hemorrhage 1(2%)	N/A	VAC	Sterile fine porous polyurethane sponge (similar to VAC; KCI Medical Ltd.) and the suction part of the negative pressure drain (Redon, Jackson Pratt)	50.8 ()		14 (30%)	
Pliakos et al. [48]	2012	2000–2009	Retrospective	27	–	Necrotizing pancreatitis 6 (22%) Pancreatic abscess 2 (7%) Purulent peritonitis 5 (18.5%) Fecal peritonitis 8 (30%) Secondary peritonitis 5 (18.5%) Necrotizing fasciitis 1 (4%)	N/A	VAC	N/A	59 (18–89)		11 (41%)	
Pliakos et al. [55]	2010	2007–2009	Prospective	15	–	Necrotizing pancreatitis 6(40%) Purulent peritonitis 6(40%) Fecal peritonitis 3(20%)	N/A	VAC	VAC® Abdominal Dressing System (KCI, San Antonio, Texas, USA)	75 (30–83)		5 (33%)	
Poillucci et al. [36]	2021	2010–2018	Retrospective	77	–	Large bowel perforation 20(25.9%) Large bowel obstruction 5(6.5%) Small bowel 17(22.1%) Postoperative fluid collection 14(18.2%) Pancreas 11(14.3%) Gallbladder 4(5.2%) Stomach 4 (5.2%) Cecal appendix 2(2.6%)	Upper 19(24.6%) Lower 44 (57.2%) Others 14(18.2%)	VAC	VAC® Abdominal Dressing System (KCI, San Antonio, Texas, USA)	64.7 (13.2)		32 (42%)	
Rajabaleyan et al. [49]	2023	2005–2018	Retrospective	20	–	Small bowel perforation 100%	Lower 100%	VAC	VAC® Abdominal Dressing System (KCI, San Antonio, Texas, USA)			12 (60%)	
Rakic et al. [61]	2005	2002–2003	Prospective	–	34	Stomach and duodenum 8(23.5%) Liver and biliary tract 1(2.9%) Pancreas 6(17.6%) Small intestine 8(23.5%) Large intestine 9(26.5%) Other 2(5.9%)	Upper 15(44%) 17(50%) 2(5.9%)	Primary closure	N/A		66.3 (17)		15 (44%)

Table 1 (continued)

Author	Year of Publication	Study Period	Study Design	N Total VAC	N Total PAC	Peritonitis Etiology (n)	Origin of Infection (Upper and Lower GI) (%)	Treatment Strategy	VAC Technique	Age VAC	Age PAC	Females VAC	Females PAC
Robledo et al. [32]	2007	1999–2001	RCT	–	20	Gastric 5(25%) Bile duct 3(15%) Duodenum/bile duct 3(15%) Jejunum 4(20%) Ileum 1(5%) Colon 2(10%)	Upper 11(55%) Lower 7(45%)	Primary closure	–		54.7 (19.3)		9 (45%)
Rosenzweig et al. [62]	2020	2014–2016	Retrospective	–	985	Colon 985(100%)	Lower 985(100%)	Primary closure	–		62.7 (14.6)		507 (51%)
Schmelzle et al. [50]	2010	2003–2008	Retrospective	49	–	Gastrointestinal malignant tumors 19(39%) Gastrointestinal perforations 13(27%) Intra-abdominal inflammation 10(20%) Obstructive ileus 6(12%) Ischemia 5(10%)	Lower 23(47%) Others 26(53%)	VAC	VAC on top of gauze and vac alone (KCI, San Antonio, TX, USA)	66 ()		23 (47%)	
Szor et al. [51]	2024	2015–2020	Retrospective	47	–	Fecal peritonitis 65.9% Mesenteric ischemia 4.2% Evisceration 23.4% Acute hemorrhagic abdomen 6.3%	N/A	VAC	–	63.1 (12.3)		25 (53%)	
Tao et al. [52]	2014	2007–2013	Retrospective	134	–	Postoperative anastomotic leakage without hemorrhage 51(38.1%) Postoperative anastomotic leakage with hemorrhage 8(6.0%) Severe acute pancreatitis 41(30.6%) Perforation of gastric/duodenal/intestine 22(16.4%) Complicated abdominal abscess 7(5.2%) Other 5(3.7%)	N/A	VAC + VAC with fluid instillation	Conventional VAC and VAC with fluid instillation	49 ()		42 (31%)	
Tartaglia et al. [53]	2021	2010–2019	Retrospective	113	–	Intestinal perforation Intestinal infarction Necrotizing infected acute severe pancreatitis Multiple abdominal abscesses	N/A	Different VAC techniques	NPWT with commercial kits 53 (46.9%) Vacuum-pack technique 38(33.6%) Skin-closure 18 (15.9%) Mesh-mediated NPWT 4 (3.5%)	68.1 (14.3)		54 (48%)	

Table 1 (continued)

Author	Year of Publication	Study Period	Study Design	N Total VAC	N Total PAC	Peritonitis Etiology (n)	Origin of Infection (Upper and Lower GI) (%)	Treatment Strategy	VAC Technique	Age VAC	Age PAC	Females VAC	Females PAC
Tolonen et al. [37]	2017	2008–2016	Retrospective	41	–	Primary colorectal perforation 15(37%) Primary small bowel perforation 2(5%) Postoperative peritonitis 24(59%) Iatrogenic small bowel perforation 10(24%) Colorectal anastomosis dehiscence 9(22%) Other anastomotic dehiscence 5(12%)	Lower 100%	VAC	VAC with mesh mediated fascial traction	59 (49.5–68)		18 (44%)	
Van Ruler et al. [33]	2007	2001–2005	RCT	–	114	Perforation 64(56%) Anastomotic leakage 36(32%) Ischemia 6(5%) Inflammation 4(4%) Other 4(4%)	Lower 71(62%) Upper 30(26%) Pancreas 5(4%) Appendix 3(3%) Biliary tract 2(2%) Gynecological 2(2%) Upper and lower gastrointestinal tract 1(1%)	Primary closure	–		65 (53–75)		61 (54%)
Wondberg et al. [54]	2008	2004–2007	Prospective	30	–	Secondary peritonitis	Upper 3(10%) Lower 26(87%) Other 1(3%)	VAC	VAC® Abdominal Dressing System (KCl, San Antonio, Texas, USA)	63 (27–86)		9 (30%)	

It includes author, year of publication, study period, design, number of patients in VAC and PAC groups, peritonitis etiologies, infection origin (upper/lower GI), treatment strategies, VAC techniques, average age, and percentage of female patients in both VAC and PAC groups

VAC Vacuum-Assisted Closure, *PAC* Primary Abdominal Closure, *GI* Gastrointestinal, *N/A* Not Applicable, *KCl* Kinetic Concepts, Inc., *NPWT* Negative Pressure Wound Therapy, *RCT* Randomized Controlled Trial

Table 2 Summarizes the primary and secondary outcomes from the meta-analysis comparing VAC and PAC

	Studies Included (VAC/PAC)	Events/ Patients VAC	Probability (%) /Mean (95%CI) VAC	Events/ Patients PAC	Probability (%) /Mean (95%CI) PAC	*P*-value for Difference	I^2 (%) (VAC)	*P*-value for $I^2 > 0$	I^2 (%) (PAC)	*P*-value for $I^2 > 0$	Egger's test (VAC)	Egger's test (PAC)
Mortality 30 days [23, 34–37, 56, 57]	5/4	107/702	0.15 [0.12; 0.18]	31/508	0.07 [0.02; 0.19]	0.0845	40.4% [0.0%; 78.0%]	0.1517	90.7% [79.2%; 95.8%]	< 0.0001	0.783	0.788
Mortality overall [22, 23, 32–36, 38–54, 58–62]	22/10	632/2003	0.31 [0.24; 0.39]	306/2036	0.22 [0.14; 0.32]	0.327	83.3% [75.8%; 88.5%]	< 0.0001	92.7% [88.7%; 95.3%]	< 0.0001	0.888	0.092
Postoperative complications [22, 33, 59, 60]	1/4	146/203	0.71 [0.65; 0.77]	332/833	0.39 [0.33; 0.45]	< 0.001	NA	NA	73.6% [26.0%; 90.6%]	0.0099	NA	0.574
Enteroatmospheric fistula [34, 36–44, 46–50, 52–54, 60]	18/1	98/1609	0.05 [0.03; 0.09]	19/197	0.09 [0.06; 0.14]	0.157	84.9% [77.5%; 89.9%]	< 0.0001	N/A	N/A	0.005	NA
Fascial closure [33, 34, 36–46, 48, 50–55]	19/1	1124/1644	0.58 [0.44; 0.70]	98/114	0.86 [0.78; 0.91]	< 0.001	94.2% [92.2%; 95.7%]	< 0.0001	N/A	N/A	0.258	NA
Incisional hernia [34, 36, 40, 55, 60]	4/1	131/617	0.21 [0.08; 0.44]	41/197	0.21 [0.15; 0.27]	0.958	92.7% [84.6%; 96.6%]	< 0.0001	N/A	N/A	0.964	NA
Intraabdominal abscess [42, 46, 49, 52, 57, 60, 61]	4/3	53/363	0.13 [0.08; 0.22]	49/297	0.12 [0.06; 0.23]	0.832	77.7% [39.6%; 91.8%]	0.0038	72.8% [8.4%; 91.9%]	0.0254	0.593	0.188
APACHE II [35, 36, 38, 51, 53, 60, 61]	5/3	N/A	19.19 [14.25; 24.13]	N/A	17.60 [9.85; 25.35]	0.739	98.3% [97.4%; 98.9%]	< 0.0001	97.3% [94.7%; 98.6%]	< 0.0001	0.722	0.299
Length of hospital stay [23, 35, 36, 51, 55, 58, 61]	5/4	N/A	49.81 [16.64; 82.98]	N/A	31.38 [22.51; 40.25]	0.303	96.7% [94.4%; 98.0%]	< 0.0001	84.6% [61.5%; 93.8%]	0.0002	0.038	0.241
Length of ICU stay [23, 35, 51, 53, 58]	4/3	N/A	21.17 [10.87; 31.47]	N/A	9.79 [8.00; 11.58]	0.037	82.8% [55.9%; 93.3%]	0.0006	18.0% [0.0%; 91.5%]	0.2953	0.022	0.301
VAC total days [36, 51, 53]	3/0	N/A	13.60 [1.17; 26.03]	N/A	N/A	N/A	97.2% [94.5%; 98.6%]	< 0.0001	N/A	N/A	0.058	NA
VAC changes [38, 53, 55]	3/0	N/A	2.63 [0.78; 4.47]	N/A	N/A	N/A	97.7% [95.6%; 98.8%]	< 0.0001	N/A	N/A	0.332	NA

Outcomes include 30-day and overall mortality rates, postoperative complications, EAFs, fascial closure rates, the incidence of incisional hernia, intra-abdominal abscess formation, APACHE II scores, lengths of hospital and ICU stays, total days of VAC therapy, and the number of VAC changes. Results are presented as probabilities or mean values along with their corresponding CIs. Heterogeneity among studies was measured using I^2, which assesses variability attributable to differences between studies. Egger's test was conducted to evaluate potential publication bias

VAC vacuum-assisted closure, *PAC* primary abdominal closure, *EAF* enteroatmospheric fistula, *APACHE II* refers Acute Physiology and Chronic Health Evaluation II, *CI* confidence interval, I^2 heterogeneity, *N/A* not applicable

complication rate, a higher fascial closure rate, and a shorter ICU length of stay. However, interpretation is limited by high heterogeneity (>75%) across most parameters and the inability to assess key demographic variables, such as comorbidities, disease severity, and physiological status. The GRADE assessment indicated that the certainty of evidence for most outcomes was low to very low, further emphasizing the need for cautious interpretation and high-quality randomized trials to clarify the comparative benefits of VAC versus PAC.

Comparative retrospective studies on VAC and PAC have shown mixed outcomes regarding mortality [22–24]. In a cohort study involving 136 patients treated with VAC and 75 patients treated with PAC, all with severe sepsis or septic shock of abdominal origin, there was a significantly lower in-hospital mortality rate for VAC 22.8% compared with PAC 38.6% [23]. Disease severity, based on the initial APACHE-IV scores at ICU admission,was similar in the two groups. In the PAC group, patients who underwent re-laparotomy had a mortality rate of 58%. In another restrospective cohort study, which included 203 patients treated with VAC and 331 patients treated with PAC, the mortality rate was 22.5% and 11.7%, respectively [22]. This discrepancy in outcomes may be attributed to selection bias, as patients in the VAC group were significantly older, exhibited greater disease severity, and required more intensive care interventions, including a higher frequency of vasopressor support (68.5% vs 23.6%) and blood transfusions (30.1% vs 9.0%) during the initial laparotomy.

Additional retrospective data suggest no significant differences in mortality at 30 days, 90 days, and 1 year between VAC and PAC [24]. Although VAC was linked to fewer surgical complications and reduced need for reoperations, it was also associated with prolonged ICU stays. The VAC group had significantly greater baseline disease severity, reflected by higher ASA, SOFA, and MPI scores, and more extensive four-quadrant contamination. These findings highlight the complexity of comparing VAC and PAC outcomes, as patient selection, disease severity, and postoperative management likely influence survival more than the closure technique itself.

Further evidence of increased illness severity in patients treated with VAC can be observed in studies reporting APACHE II scores. Poillucci et al. [36] reported a mean APACHE II score of 27.5, with a corresponding mortality rate of 35%. There was an APACHE II score of 15.3 and a mortality rate of 43.3% in the study by Tartaglia et al. [53], while there was a score of 13.9 and a mortality rate of 23.8% in the study by Tao et al. [52]. In contrast, Lamme et al. [60] reported that their PAC group had a lower mean APACHE II score of 10.8, with a mortality rate of 21.8%. Our analysis indicated an average APACHE II score of 19.19 for the VAC group and 17.60 for the PAC group, with no significant difference between the groups. The average overall mortality rate in our study was 31.1% in the VAC group and 22.2% in the PAC group. However, these findings are based on a limited number of studies with substantial heterogeneity.

The rate of postoperative complications in this systematic review was significantly higher in patients treated with VAC, with a rate of 73%, compared with 39.3% in patients treated with PAC. This difference could be explained by patient selection bias, as the more severe nature of cases managed with VAC likely accounts for the higher complication rates. However, postoperative complication reporting varied markedly between the included studies, complicating direct comparisons.

Studies reporting postoperative complications in patients treated with PAC include Bensignor et al. [59] who reported that 46% of patients treated with PAC experienced complications graded >2 based on the Clavien–Dindo classification. Lamme et al. [60] reported surgically related complications, irrespective of severity, in 43% of patients treated with PAC. Van Ruler et al. [33], who focused on peritonitis-related complications, found a lower rate of 28% in patients treated with PAC.

In a comparative study including both treatment modalities, Kao et al. [22] reported a postoperative complication rate of 71% in patients treated with VAC compared with 38% in patients treated with PAC. These discrepancies in reporting methodologies complicate the comparison of postoperative complication outcomes in studies involving both VAC and PAC treatments. While the Clavien-Dindo classification is used in some studies to report postoperative complications, its applicability in emergency laparotomies can be questioned, particularly as these patients often require multiple reoperations.

The incidence of EAF was lower in the VAC group 5.82% compared with the PAC group 9.64%, but the limited number of studies reporting on EAF in patients treated with PAC complicates interpretation. The development of EAF is multifactorial, influenced by factors such as sepsis and prolonged open abdomen management [63, 64]. There is no established relationship between peritonitis, VAC, and the incidence of EAF, and the available evidence remains inconclusive [20].

The overall completed fascial closure rate in our study was significantly lower in patients treated with VAC 58.13% compared with patients treated with PAC 85.96%, which might reflect difficulties in managing complex open abdomen cases. Patient-specific factors, such as peritonitis fascial retraction and fascial necrosis, further complicate closure outcomes in patients treated with VAC [39, 65]. Combining VAC with mesh-mediated fascial traction improves the delayed primary closure rate

compared with VAC alone. Tao et al. [52] reported a higher rate of delayed closure, 63% with mesh-mediated fascial traction versus 41% with VAC alone. Similarly, Atema et al. [25] observed a closure rate of 73.1% with this combined approach.

Incisional hernias remain a significant complication after surgical management of secondary peritonitis. In this study, the pooled incidence of hernias was 21.3% in the VAC group and 20.8% in the PAC group. However, the latter was based on only one study. Given the similar rate for both approaches, no clear difference in risk can be concluded. While mechanical stress and delayed fascial closure in VAC may contribute to hernia formation [25, 66], immediate closure in PAC does not seem to offer a substantial advantage in this regard. These findings are consistent with previous studies: some have reported similar rates, while others have shown a higher incidence in the VAC group [34, 36, 55, 60].

Intra-abdominal abscesses are another common and serious complication following surgery for secondary peritonitis. In this study, the incidence of abscesses was 13.9% for the VAC group and 12.7% for the PAC group. The formation of these abscesses is often due to persistent infection or inadequate source control during the initial surgery, requiring additional interventions such as percutaneous drainage or repeat surgical procedures [11, 13]. However, when interpreting these results, it is important to consider whether the abscesses in the VAC group were detected and treated during VAC changes or developed after secondary closure. This distinction is not clearly addressed in the included studies, but it may be relevant for understanding the reported outcomes. These abscesses complicate recovery and contribute to prolonged hospital stays, highlighting the importance of effective infection control measures during the initial surgical intervention [7].

The hospital and ICU length of stay was longer in patients treated with VAC. This extended duration reflects the need for ongoing intensive care. Frequent VAC dressing changes and the need for prolonged monitoring likely contribute to prolonged hospitalisation.

Despite the global adoption of VAC, strong comparative evidence between VAC and PAC with ROD is limited. Most studies rely on the surgeon's preference for VAC, introducing variability and restricting definitive conclusions. VAC does not show a clear advantage or disadvantage over ROD in managing secondary peritonitis. The results from ongoing RCTs are essential for establishing the efficacy of VAC compared with PAC and ROD strategies [67, 68].

The sensitivity analysis, restricted to a limited number of studies per outcome, demonstrated consistent results with the primary analysis for mortality outcomes, with no significant differences observed in 30-day or overall mortality. However, substantial heterogeneity in overall mortality and hospital stay reflects methodological and clinical variability among the included studies. The significantly longer ICU stay observed in the VAC group persisted even in this restricted dataset, suggesting a potential association between VAC therapy and increased intensive care resource utilization. While these findings lend support the primary results, the limited number of contributing studies warrants cautious interpretation.

This systematic review has several limitations. The included studies exhibited substantial heterogeneity, particularly in mortality, postoperative complications, and fascial closure rates, reflecting differences in patient populations, treatment protocols, and study designs. This variability weakened pooled analyses for some secondary outcomes. The predominance of retrospective studies increased the risk of selection bias due to non-randomized treatment allocation, which was influenced by factors such as disease severity and clinician preference. While APACHE II scores were reported in only a few studies and used to assess baseline severity, no formal adjustments for confounding were performed, limiting the ability to account for differences in patient characteristics. Variability in study quality, including small sample sizes and incomplete follow-up, further affected the reliability of long-term outcomes.

The $\geq 50\%$ peritonitis threshold ensured clinical relevance while maintaining a sufficiently large dataset, aligning with previous reviews [25]. A stricter threshold would have limited available evidence, while a lower one risked diluting the focus on secondary peritonitis. Furthermore, studies that did not report peritonitis outcomes separately were excluded, requiring data extraction specific to these patients to enhance reporting and maintain focus. However, we acknowledge this as a limitation, as it may have introduced selection bias and affected the generalizability of findings.

Assessment of publication bias revealed small-study effects in several outcomes, including 30-day mortality (PAC), postoperative complications (VAC), EAF (VAC), and hospital length of stay (VAC), suggesting potential overestimation of treatment effects in smaller studies. In contrast, outcomes such as secondary fascial closure (PAC), VAC treatment duration, and dressing changes showed low risk of bias. These findings highlight the need for cautious interpretation of results, particularly in outcomes with significant Egger's test findings or visual funnel plot asymmetry.

The GRADE assessment confirmed that most outcomes had low to very low certainty due to study design

limitations, heterogeneity, and imprecision. These findings emphasize the need for cautious interpretation, as study bias and variability may influence effect estimates more than actual clinical differences. Additionally, risk-of-bias assessment revealed that the two included RCTs differed in quality, with one exhibiting a high risk of bias due to issues in randomisation and deviations from intended interventions, while the other had some concerns. Observational studies generally carried a high risk of bias, primarily due to confounding, selection bias, and lack of blinding, further limiting the robustness of the findings.

Despite these limitations, this review provides a comprehensive synthesis of current evidence comparing VAC and PAC with ROD in secondary peritonitis, highlighting the need for high-quality prospective studies.

Conclusion

The open abdomen strategy with VAC in the surgical treatment of secondary peritonitis did not show a significant difference in mortality compared with PAC. However, PAC demonstrated a significantly lower postoperative complication rate, a higher fascial closure rate, and a shorter ICU length of stay. GRADE assessment confirmed that most outcomes had low to very low certainty.

Abbreviations

APACHE	Acute Physiology and Chronic Health Evaluation
ASA	American Society of Anesthesiologists
BMI	Body Mass Index
CCI	Charlson Comorbidity Index
EAF	Enteroatmospheric Fistula
GRADE	Grading of Recommendations, Assessment, Development, and Evaluation
ICU	Intensive Care Unit
MPI	Mannheim Peritonitis Index
MOOSE	Meta-analysis of Observational Studies in Epidemiology
NPWT	Negative Pressure Wound Therapy
PAC	Primary Abdominal Closure
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
RCT	Randomised Controlled Trial
ROD	Relaparotomy On Demand
VAC	Vacuum-Assisted Closure

Supplementary Information

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Additional file 1.
Additional file 2.
Additional file 3.
Additional file 4.
Additional file 5.
Additional file 6.
Additional file 7.
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Additional file 18.
Additional file 19.
Additional file 20.
Additional file 21.
Additional file 22.
Additional file 23.
Additional file 24.

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Author contributions

The study was conceptualised by PR, PC, SM, and MBE. The methodology was developed by PR, PC, SM, NQ, and MBE. PR was responsible for validation. Formal analysis was conducted by PR and SM. Data curation was managed by PR, PC, SM, NQ, and MBE. The original draft of the manuscript was written by PR, and PR, PC, SM, NQ, and MBE contributed to the review and editing process.

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Availability of data and materials

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The systematic review adhered to the PRISMA 2020 guidelines, was registered in PROSPERO (CRD42021265160), and relied solely on published data, eliminating the need for additional ethical approval.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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