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REVIEW

Prophylactic mesh augmentation in emergency laparotomy closure: a meta-analysis of randomized controlled trials with trial sequential analysis

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Abstract

Background Prophylactic mesh augmentation in emergency laparotomy closure is controversial. We aimed to perform a meta-analysis of randomized controlled trials (RCT) evaluating the placement of prophylactic mesh during emergency laparotomy.

Methods We performed a systematic review of Cochrane, Scopus, and PubMed databases to identify RCT comparing prophylactic mesh augmentation and no mesh augmentation in patients undergoing emergency laparotomy. We excluded observational studies, conference abstracts, elective surgeries, overlapping populations, and trial protocols. Postoperative outcomes were assessed by pooled analysis and meta-analysis. Statistical analysis was performed using RevMan 5.4. Heterogeneity was assessed with I^2 statistics. Risk of bias was assessed using the revised Cochrane risk-of-bias tool (RoB 2). The review protocol was registered at PROSPERO (CRD42023412934).

Results We screened 1312 studies and 33 were thoroughly reviewed. Four studies comprising 464 patients were included in the analysis. Mesh reinforcement was significantly associated with a decrease in incisional hernia incidence (OR 0.18; 95% CI 0.07–0.44; $p < 0.001$; $I^2 = 0\%$), and synthetic mesh placement reduced fascial dehiscence (OR 0.07; 95% CI 0.01–0.53; $p = 0.01$; $I^2 = 0\%$). Mesh augmentation was associated with an increase in operative time (MD 32.09 min; 95% CI 6.39–57.78; $p = 0.01$; $I^2 = 49\%$) and seroma (OR 3.89; 95% CI 1.54–9.84; $p = 0.004$; $I^2 = 0\%$), but there was no difference in surgical-site infection or surgical-site occurrences requiring procedural intervention or reoperation.

Conclusions Mesh augmentation in emergency laparotomy decreases incisional hernia and fascial dehiscence incidence. Despite the risk of seroma, prophylactic mesh augmentation appears to be safe and might be considered for emergency laparotomy closure. Further studies evaluating long-term outcomes are still needed.

Keywords Mesh · Laparotomy · Fascial dehiscence · Inguinal hernia

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Introduction

Emergency laparotomy is a frequently performed surgical procedure for various medical conditions, including abdominal trauma, bowel obstruction, and bowel perforation [1]. With around 5 million such procedures annually in the US alone, the importance of effectively sealing the abdominal wall post-surgery cannot be overstated [2]. Effective closure of the abdominal wall is critical in preventing early complications, notably fascial dehiscence (FD), as well as long-term issues such as incisional hernias (IH). Therefore, proper abdominal wall closure is essential to minimize complications.

Current best practices for the closure of abdominal walls after laparotomy frequently utilize a running suture that is slowly absorbable [3]. Additionally, techniques such as "small bites" have been explored to potentially decrease the incidence of IH [3]. Despite these innovations, the prevalence of IH remains concerning, with some studies reporting rates as high as 13% [2]. Within this backdrop, prophylactic mesh implantation has emerged in research as a promising strategy to curb the incidence of IH, especially among high-risk patients [4]. Notably, patients undergoing emergent laparotomy face a substantially higher risk of complications like FD and IH compared to those having elective surgeries [5]. Yet, the use of prophylactic mesh in emergency laparotomies is a topic of debate. The Updated Guideline for Closure of Abdominal Wall Incisions emphasizes the current uncertainty, stating that due to limited available evidence, no firm recommendation can be made regarding prophylactic mesh augmentation after emergent laparotomy [3].

A previously published meta-analysis underscored that mesh augmentation in emergency laparotomies significantly reduced FD and IH incidents [6]. However, the inclusion of observational studies in that analysis might have skewed the findings due to potential biases. Recognizing this gap and the emergence of new research, including two randomized controlled trials (RCTs) [7, 8]. In order to reduce bias, we aimed to perform a more rigorous systematic review and meta-analysis, including only RCTs, to evaluate the effectiveness and safety of prophylactic mesh use in emergency laparotomies.

Materials and methods

Eligibility criteria

Inclusion in this meta-analysis was restricted to studies that met all the following eligibility criteria: (1) RCT; (2) comparing mesh reinforcement and suture closure; (3) in patients undergoing emergency laparotomy; (4) reported postoperative outcomes; (5) in English, Portuguese, or Spanish. We excluded observational studies, conference abstracts, studies with only elective surgeries, studies with overlapping populations, RCT protocols, and studies that did not report outcomes on emergent laparotomy only. The review protocol was registered at PROSPERO (CRD42023412934).

Search strategy and data extraction

We systematically searched MEDLINE, Scopus, and Cochrane Central Register of Controlled Trials (CENTRAL) from inception to April 2023 with the following search terms: "prophylactic", "augmentation", "reinforcement", "mesh", "prosthesis", prosthetic", "emergent", "urgent", "laparotomy". Reference lists from previous reviews and all included studies were searched for any additional studies. Two researchers (PM and BOT) independently screened articles for inclusion criteria and extracted data from full-text journals and published appendices of included studies. Any disagreements were resolved through consensus or, if necessary, by a third author (SMPF).

Outcomes of interest

The primary endpoint of our analysis was fascial dehiscence (FD). Secondary outcomes included incisional hernia (IH) at 1-year, surgical-site infections (SSI), seromas, hematomas, operative time, and composite postoperative outcomes (surgical-site occurrences requiring procedural intervention [SSOPI] and surgical-site occurrences [SSO] requiring reoperation). SSO is defined as a wound event that is not captured by SSI and includes complications, such as seroma, hematoma, or enterocutaneous fistula [9]. Data were independently assessed by two authors (PM and BOT), and results of individual studies and syntheses were tabulated using Microsoft Excel®.

Quality assessment

Quality assessment and risk of bias in individual studies were assessed by two authors independently (PM and BOT) using the revised Cochrane risk-of-bias tool (RoB 2) [10], in which studies are categorized as 'low' risk, 'high' risk, or may express 'some concerns' in five domains: randomization, deviations from intended intervention, missing outcome data, measurement of the outcome, and selection of the reported result. A quality assessment summary for each article was created with the Risk of Bias Visualization Tool (ROBVIS) [11].

Statistical analysis

This meta-analysis was performed according to the Cochrane Collaboration and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement guidelines [12]. Dichotomous endpoints were reported as frequencies and continuous variables as mean ± standard deviation. Odds ratios (OR) with 95% confidence intervals (CI) were used to compare the incidence of categorical endpoints between intervention and control groups while mean difference was used for continuous endpoints. Cochran Q test and I^2 statistics were used to assess for heterogeneity. Endpoints were considered to have low heterogeneity if $p > 0.10$ and $I^2 < 25\%$, moderate heterogeneity if I^2 between 25% and 75% and high heterogeneity if $I^2 > 75\%$. We used a fixed-effect model for outcomes with low heterogeneity ($I^2 < 25\%$). Otherwise, we used DerSimonian and Laird random-effects model to calculate the pooled effect estimates. p values of < 0.05 were considered statistically significant. Review Manager 5.4 (Cochrane Centre, The Cochrane Collaboration, Denmark) was used for statistical analysis. We performed subgroup analyses of studies that used synthetic mesh. We performed a sensitivity analysis for statistically significant outcomes that had data from at least three studies by systematically removing each study from the pooled estimates. Finally, in order to control for random errors due to sparse data and repetitive testing of accumulating data, trial sequential analysis (TSA) was performed for the primary outcome (TSA software version 0.9.5.10 Beta; Copenhagen Trial Unit, Center for Clinical Intervention Research, Rigshospitalet, Copenhagen, Denmark) [13]. We used a model assuming a type-1 error α of 2.5% and a power $(1-\beta)$ of 80%. We estimated the required information size based on the observed proportion of patients with an outcome in the control group, and using relative risk reduction based on the results of the studies categorized as low risk of bias, which is autogenerated by the software, as well as a D^2 using a variance-based model. If the measured D^2 was zero, a D^2 of 25% was used [14].

Certainty assessment

Certainty of evidence was assessed using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach [15]. We assessed the certainty of evidence for each outcome as high, moderate, low, or very low based on the study design, risk of bias, inconsistency, indirectness, imprecision, and publication bias.

Results

Study selection and characteristics

Four RCTs were included, comprising 464 patients: 234 in the mesh group and 230 in the no mesh group [7, 8, 16, 17]. The search process is summarized in Fig. 1. The baseline characteristics of the included studies are described in Table 1. Most of the prophylactic mesh used was synthetic (91%) and placed in an onlay position (48.3%). Mesh overlap varied from 2 to 5 cm. Regarding fascial closure, all studies used a running PDS suture with a suture length to wound length ratio of 4:1. The surgical indications for emergency laparotomy in the overall sample primarily consisted of non-traumatic conditions, such as bowel obstructions and perforated viscus. It is important to highlight that while the studies conducted by Jakob and Lima provided detailed information regarding surgical intervention indication, Ulutas et al. did not provide specific patient numbers for the listed indications, and the PROMETHEUS trial did not provide any information about indication for emergency surgery. Surgical details of included studies are described in Table 2. The sample was mostly composed of men (51.5%). Seventy-one patients were diabetic (15.3%), 44 had chronic obstructive pulmonary disease (9.5%), 88 were smokers (19%), and 87 had prior abdominal surgeries (18.8%). Mean age varied from 54.7 to 71 years, and mean BMI varied from 24.8 to 28.8 kg/m^2. Most patients were classified as American Society of Anesthesiologists (ASA) Physical Status Classification 2 (42.4%), and most wounds were classified as clean-contaminated (76.9%).

Pooled analysis of all studies

Fascial dehiscence

The incidence of FD was reported in four studies (Fig. 2A). Conventional meta-analysis showed no difference in FD between mesh placement and no mesh (OR 0.31; 95% CI 0.02–5.87; $p = 0.44$; $I^2 = 71\%$). TSA showed that cumulative Z-curves did not cross both conventional and trial sequential monitoring boundaries. In addition, the cumulative sample size did not reach the required information size of 4429 (Fig. 2B).

In the subgroup analysis of synthetic mesh only (Fig. 3A), meta-analysis showed a statistically significant difference in FD between mesh placement and no mesh (OR 0.07; 95% CI 0.01–0.53; $p = 0.01$; $I^2 = 0\%$), with lower rates of FD seen with the use of synthetic mesh. Although TSA showed that the cumulative sample size did not reach the required information size of 638, the

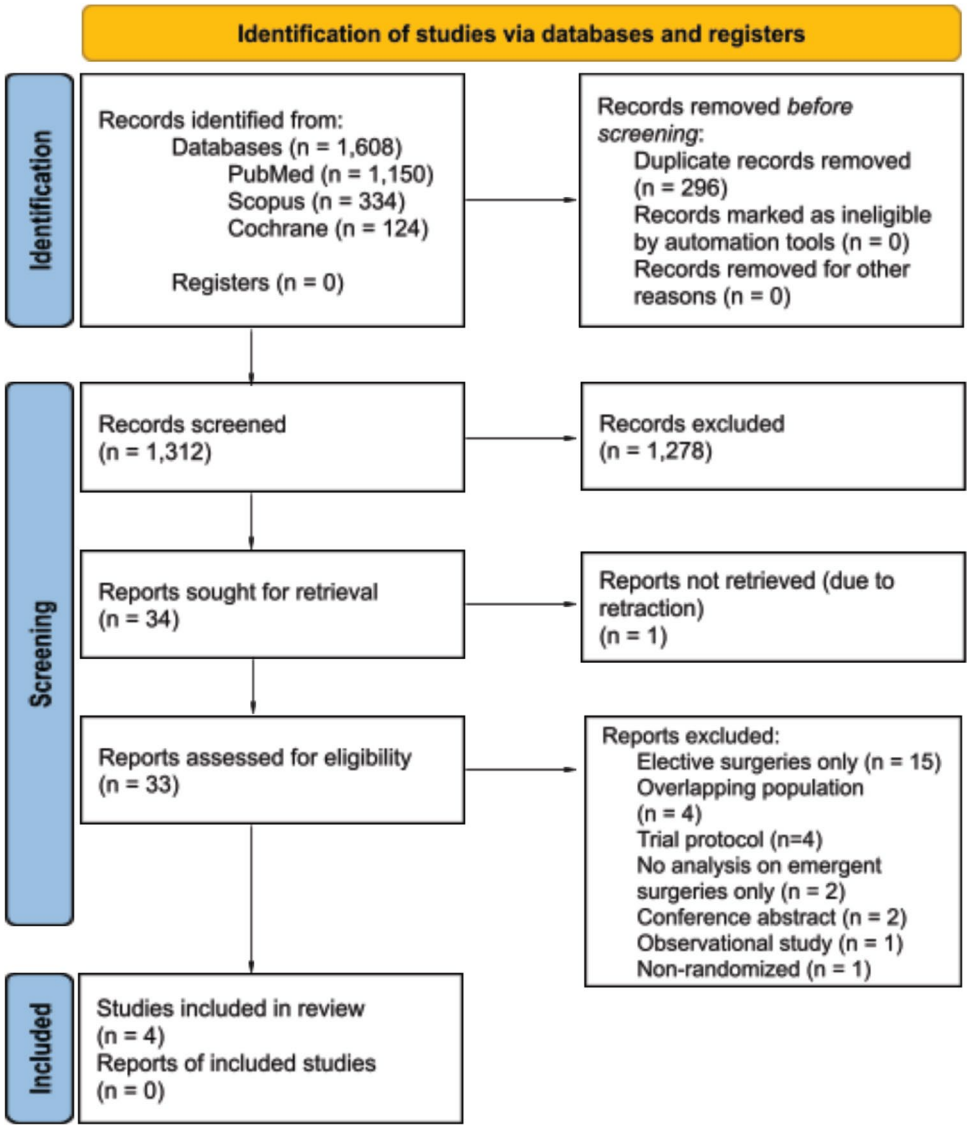

Fig. 1 PRISMA flow diagram of study screening and selection

cumulative Z-curves crossed both conventional and trial sequential monitoring boundaries (Fig. 3B).

Incisional hernia

The incidence of IH was reported in two studies (Fig. 4); both used synthetic mesh. Meta-analysis showed a statistically significant difference in IH between mesh placement and no mesh (OR 0.18; 95% CI 0.07–0.44; $p = 0.0002$; $I^2 = 0\%$), with lower rates of IH seen in the mesh group.

Seroma

The incidence of seroma was reported in four studies (Fig. 5A). Meta-analysis showed a statistically significant higher rate of seroma in the mesh group (OR 3.89; 95% CI 1.54–9.84; $p = 0.004$; $I^2 = 0\%$). After sensitivity analysis, the results were unchanged. In the subgroup analysis of synthetic mesh only (Fig. 5B), meta-analysis showed a statistically significant higher rate of seroma in the mesh group (OR 3.89; 95% CI 1.54–9.84; $p = 0.004$; $I^2 = 0\%$).

Surgical-site infection

The incidence of SSI was reported in four studies (Fig. 6A). Meta-analysis showed no difference in SSI between mesh placement and no mesh (OR 1.45; 95% CI 0.78–2.69; $p = 0.24$; $I^2 = 3\%$). In the subgroup analysis of synthetic mesh only (Fig. 6B), meta-analysis showed no difference in SSI between mesh placement and no mesh (OR 1.77; 95% CI 0.88–3.53; $p = 0.11$; $I^2 = 0\%$).

Table 1 Baseline characteristics of included studies

Study	Patients, *n* MG/NMG	Male, *n* MG/NMG	Age[δ], y MG/NMG	BMI[δ], kg/m^2 MG/NMG	Diabetes, % MG/NMG	COPD, % MG/NMG	Smoking, % MG/NMG	Prior abdominal surgery, % MG/NMG	ASA class, % MG/NMG	Wound class, % MG/NMG	Follow-up, mo MG/NMG
Jakob [16]	21/27	13/15	69 (11)/71 (15)[§]	25.5 (4.2)/25.4 (8)[§]	4.8/22.2	9.5/33.3[¶]	–	57.1/70.4	ASA 1: 0/0 ASA 2: 28.6/22.2 ASA 3: 42.9/22.2 ASA 4: 23.8/48.1 ASA 5: 4.8/7.4	–	25*
Lima [17]	63/52	35/31	61 ± 12.6/66.1 ± 12.3	26 ± 7.3/24.8 ± 5	9.5/21.2	6.4/3.8	20.6/13.5	11.1/17.3	ASA 1: 14.5/17.3 ASA 2: 49.2/42.3 ASA 3: 34.9/40.4 ASA 4: 1.6/0 ASA 5: 0/0	I: 0/0 II: 58.7/55.8 III: 15.9/17.3 IV: 25.4/26.9	1
Pizza [8] (PROMETHEUS)	100/100	38/48	65.8 (19–88)/66.1 (22–85)[†]	28.8 (19–34)/28.6 (22–34)[†]	11/13	8/13	13/16	15/8	–	I: 0/0 II: 100/100 III: 0 IV: 0	24
Ulutas [7]	50/51	34/25	54.7 ± 19.9/57.1 ± 21.3	27.1 ± 4.4/26.7 ± 4.9	20/25.5	0/11.8	44/33.3	16/17.6	ASA 1: 6/7.9 ASA 2: 54/39.2 ASA 3: 20/45 ASA 4: 20/7.9 ASA 5: 0/0	I: 24/9.8 II: 48/58.8 III: 0/2 IV: 28/29.4	12

*Time after the inclusion of the first patient; *ASA* American association of anesthesiologists; *I* clean; *II* clean-contaminated; *III* contaminated; *IV* dirty-Infected; *MG* mesh group; *NMG* no mesh group

[δ]Mean ± standard deviation

[§]Median (interquartile range)

[†]Median (range)

[¶]Pulmonopathy

Table 2 Surgical details of included studies

Study	Fascial closure technique	Type of mesh	Mesh position	Mesh overlap	Mesh fixation
Jakob [16]	Large-bite technique using running looped 1 PDS SL/WL ratio of 4:1	Acellular porcine dermal matrix biologic mesh—Strattice™ (Allergan, Dublin, Ireland)	IPOM	At least 5 cm in all directions	2–0 prolene and 2–0 PDS sutures
Lima [17]	Small-bite technique using running 0 PDS SL/WL ratio of 4:1	Heavyweight polypropylene mesh—Intracorp® (Venkuri, Brazil) or Abdotex® (Barone, Brazil)	Onlay	3 cm in all directions	Running 2–0 vicryl
Pizza [8] (PROMETHEUS)	Running 0 PDS SL/WL ratio of 4:1	Self-gripping monofilament polyester and resorbable polylactic acid—Parietex ProGrip™ (Medtronic, Trevoux, Francia)	Retromuscular	2 cm in all directions	N/A
Ulutas [7]	Small-bite technique using running 2–0 PDS SL/WL ratio of 4:1	Partly absorbable lightweight polypropylene mesh—Ultrapro™ (Ethicon, NJ, USA)	Onlay	5 cm	2–0 prolene and 2–0 PDS sutures

IPOM Intraperitoneal onlay mesh, *PDS* polydioxanone, *SL/WL* suture length to wound length

Deep surgical-site infection

The incidence of deep SSI was reported in four studies (Fig. 7A). Meta-analysis showed no difference in deep SSI between mesh placement and no mesh (OR 1.84; 95% CI 0.35–9.65; $p=0.47$; $I^2=18\%$). In the subgroup analysis of synthetic mesh only (Fig. 7B), meta-analysis showed no difference in deep SSI between mesh placement and no mesh (OR 1.01; 95% CI 0.20–5.08; $p=0.99$; $I^2=0\%$).

Hematoma

The incidence of hematoma was reported in four studies (Fig. 8A). Meta-analysis showed no difference in hematoma rates between mesh placement and no mesh (OR 1.39; 95% CI 0.46–4.25; $p=0.56$; $I^2=0\%$). In the subgroup analysis of synthetic mesh only (Fig. 8B), meta-analysis showed no difference in hematoma rates between mesh placement and no mesh (OR 1.41; 95% CI 0.42–4.75; $p=0.58$; $I^2=0\%$).

Surgical-site occurrences requiring procedural intervention

The incidence of SSOPI was reported in four studies (Fig. 9A). Meta-analysis showed no difference in SSOPI rates between mesh placement and no mesh (OR 1.34; 95% CI 0.33–5.47; $p=0.68$; $I^2=60\%$). In the subgroup analysis of synthetic mesh only (Fig. 9B), meta-analysis showed no difference in SSOPI rates between mesh placement and no mesh (OR 0.76; 95% CI 0.23–2.56; $p=0.66$; $I^2=40\%$).

Surgical-site occurrences requiring reoperation

The incidence of SSO requiring reoperation was reported in four studies (Fig. 10A). Meta-analysis showed no difference in SSO requiring reoperation rates between mesh placement and no mesh (OR 1.76; 95% CI 0.29–10.75; $p=0.54$; $I^2=55\%$). In the subgroup analysis of synthetic mesh only (Fig. 10B), meta-analysis showed no difference in SSO requiring reoperation rates between mesh placement and no mesh (OR 0.97; 95% CI 0.10–9.25; $p=0.98$; $I^2=57\%$).

Operative time

Operative time was reported in four studies (Fig. 11). Meta-analysis showed a statistically significant longer in operative time in mesh group (MD 32.09 min; 95% CI 6.39–57.78; $p=0.01$; $I^2=49\%$).

Quality assessment

GRADE assessment is provided in Supplemental Digital Content 1. Overall, studies were classified as having a low risk of bias. Individual appraisal of each study included in the meta-analysis is shown in Supplemental Digital Content 1. Funnel plots are less informative with such a small sample size, and using the Egger test is not advised unless a minimum of 10 studies are being analyzed [18].

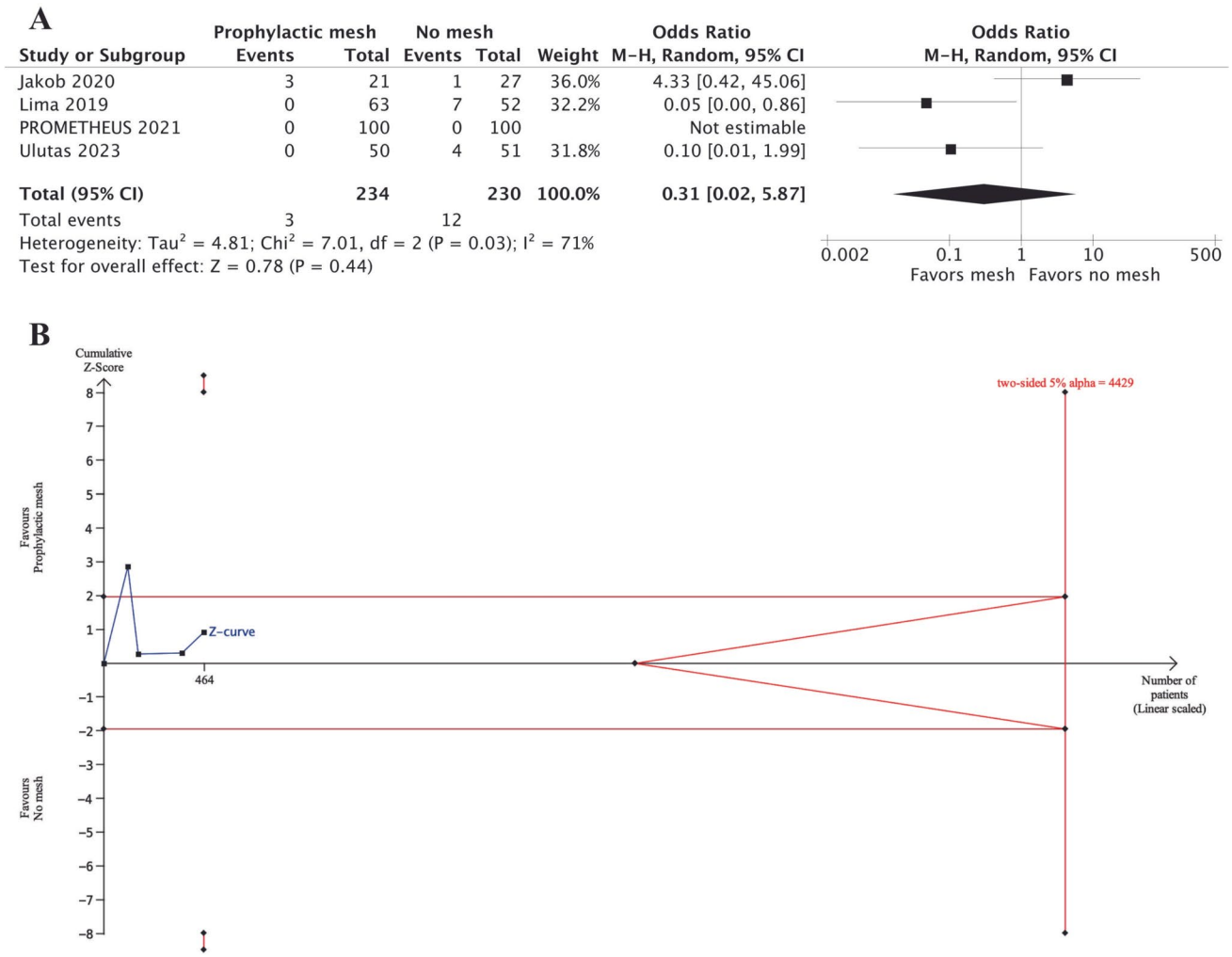

Fig. 2 **A** Forest plot on the incidence of fascial dehiscence after emergency laparotomy. **B** Trial sequential analysis on the incidence of fascial dehiscence after emergency laparotomy

Discussion

In this systematic review and meta-analysis comprising four studies and 464 patients, we evaluated the effect of prophylactic mesh augmentation on emergency laparotomy closure. Our findings indicate that mesh augmentation lowers the incidence of IH and that the use of synthetic mesh reduces FD, a conclusion further supported by the trial sequential analysis. While mesh placement is associated with a higher incidence of seroma formation, it does not lead to an increased need for procedural intervention or reoperation.

Laparotomy incisions after abdominal surgery often lead to complications, such as FD and IH. In fact, Moussavian et al. highlighted this concern, documenting a significant 54% IH rate after 6 years in patients who underwent emergency laparotomy [19]. Mesh placement has been proposed as a strategy to reduce the incidence of these complications. However, concerns have been raised about the potential for SSO, particularly in emergency surgery cases [20].

FD is a serious complication of laparotomy that affects up to 10% of patients [21]. Patients with this complication have a 45% mortality risk and an 80% risk of developing an IH [22–24]. In the overall analysis, we did not find a significant difference for FD between mesh placement and no mesh. However, when we analyzed the subgroup of studies that used synthetic mesh, we found that mesh placement reduced FD. This result is in accordance with the RCT by Ulutas et al. which included 108 patients and found a 7.8% incidence of FD in the suture group compared to 0% in the prophylactic mesh group ($p=0.04$) [7]. Thus, the use of synthetic mesh may be a valuable strategy for reducing the risk of FD in emergency laparotomy patients.

IHs remain a persistent challenge post-laparotomy, making the length of follow-up crucial [25]. Two out of the four studies that we included had a sufficiently long follow-up

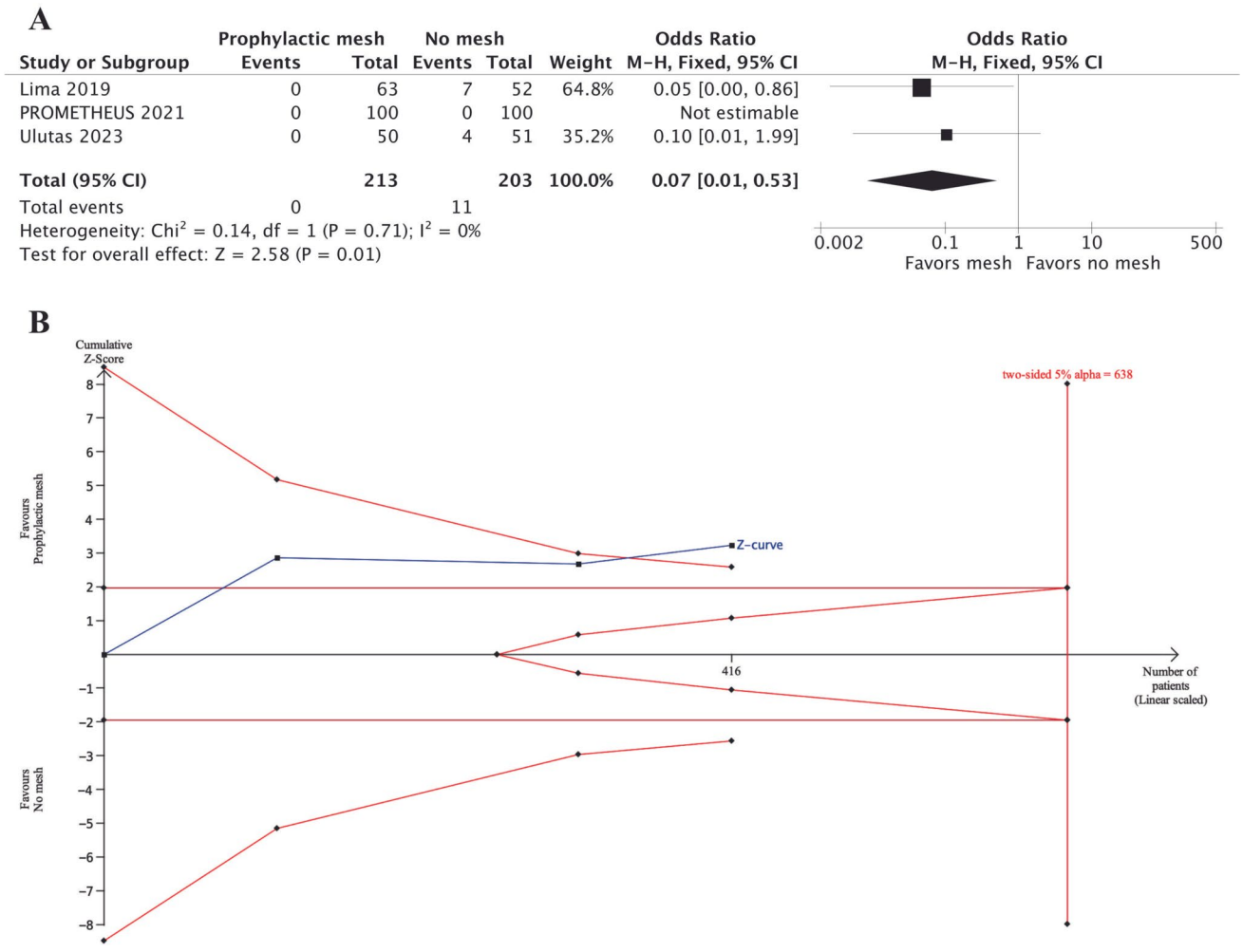

Fig. 3 **A** Subgroup analysis of synthetic mesh on incidence of fascial dehiscence after emergency laparotomy. **B** Trial sequential analysis on subgroup of synthetic mesh on incidence of fascial dehiscence after emergency laparotomy

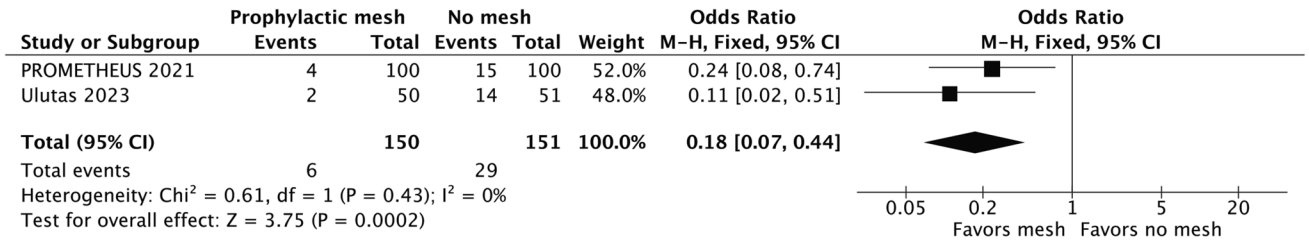

Fig. 4 Forest plot on the incidence of incisional hernia at 1 year after emergency laparotomy

period to enable reporting on the incidence of IH. In our pooled analysis, the incidence of IH in the mesh group at 1 year was 4% in contrast to 19.2% in the no mesh group, and prophylactic mesh placement was associated with a 79% reduction on IH at 1 year. In the PROMETHEUS trial, which had a 24-month follow-up period, 21% of the patients in the suture group and 6% in the mesh group developed an IH [8].

While the use of mesh has been shown to decrease the incidence of IH, there is concern about the potential for wound complications, particularly in emergency cases [26]. Our analysis found that mesh placement was significantly associated with the development of seromas, which is consistent with a study of elective laparotomies that found increased seroma rates in the mesh group (OR 2.686; 95%

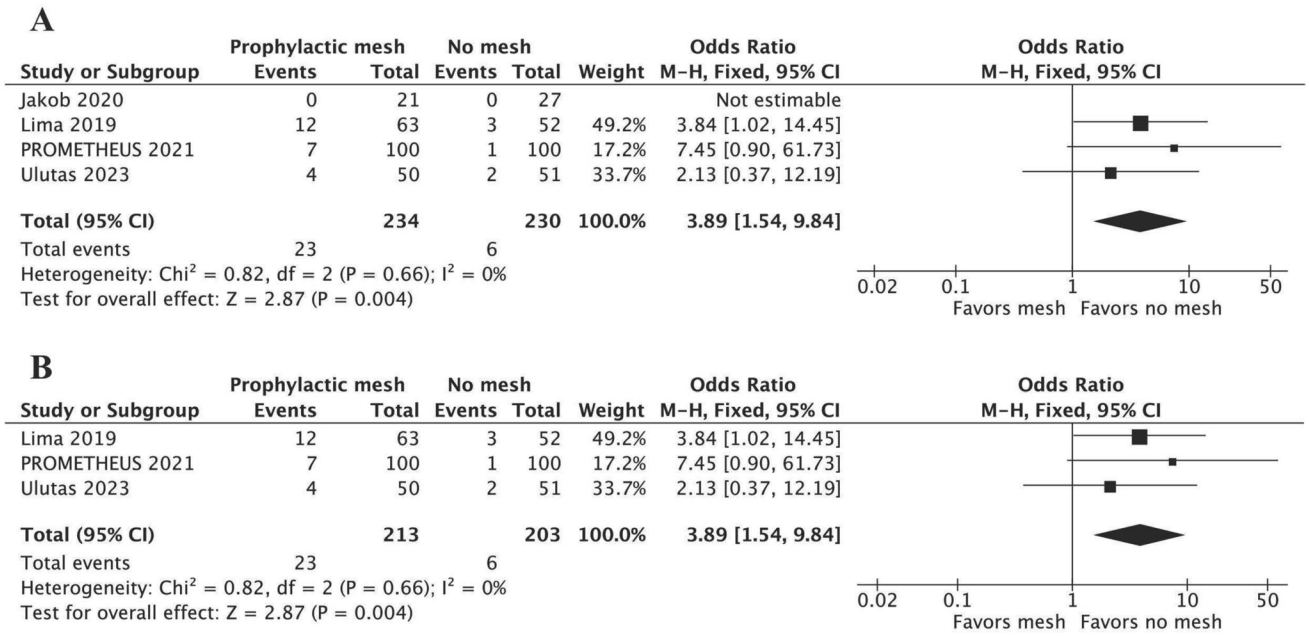

Fig. 5 **A** Forest plot on the incidence of seroma after emergency laparotomy. **B** Subgroup analysis of synthetic mesh on incidence of seroma after emergency laparotomy

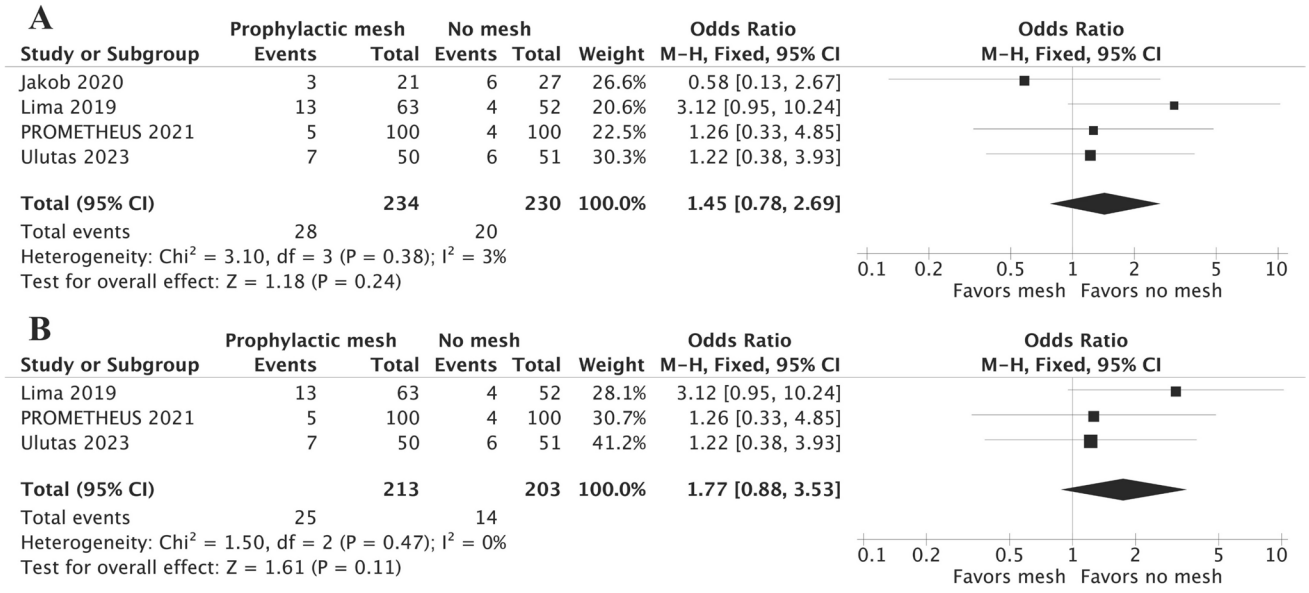

Fig. 6 **A** Forest plot on the incidence of SSI after emergency laparotomy. **B** Subgroup analysis of synthetic mesh on incidence of SSI after emergency laparotomy

CI 1.10–6.54; $p = 0.029$) [27]. However, we also found no significant difference regarding SSOPIs, suggesting that most of these seromas can be treated conservatively and with minimal clinical impact.

Biologic mesh has garnered considerable attention due to its hypothetical advantages over synthetic mesh, particularly in contaminated settings [28]. In our review, the only published RCT using an intraperitoneal biologic mesh had to be prematurely terminated due to safety concerns. The authors found that complications requiring reoperation were greater in the mesh group (38.5% vs. 7.7%; $p = 0.026$) [16]. This concern correlates with a recent meta-analysis comparing biologic and synthetic mesh in ventral hernia repair in which biologic mesh is associated with increased infectious

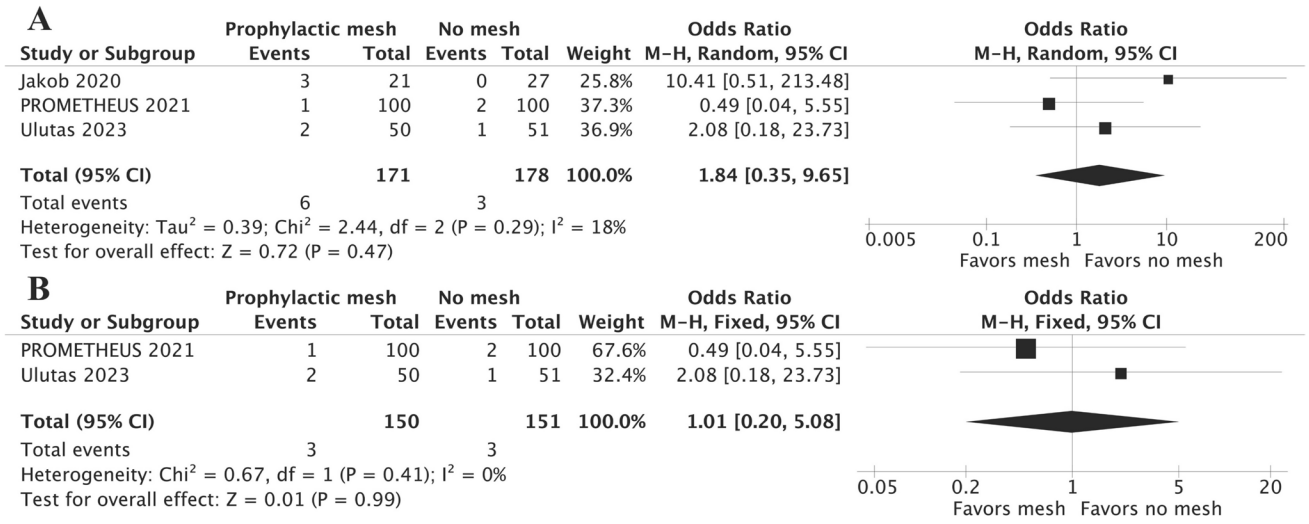

Fig. 7 **A** Forest plot on the incidence of deep SSI after emergency laparotomy. **B** Subgroup analysis of synthetic mesh on incidence of deep SSI after emergency laparotomy

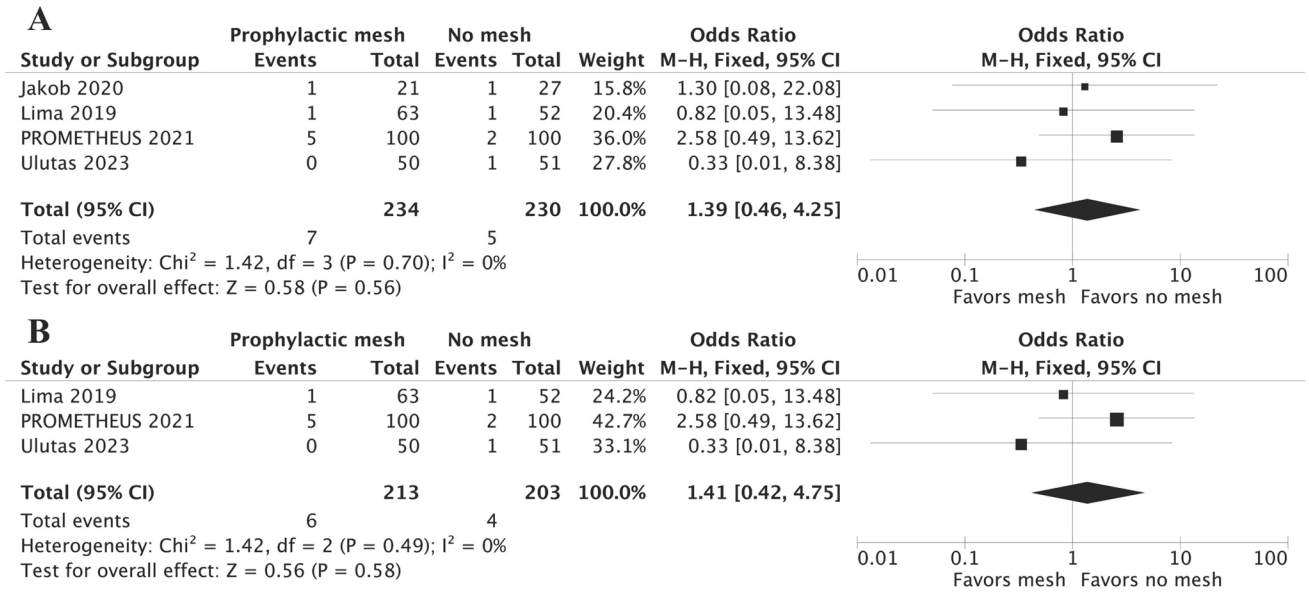

Fig. 8 **A** Forest plot on the incidence of hematoma after emergency laparotomy. **B** Subgroup analysis of synthetic mesh on incidence of hematoma after emergency laparotomy

complications [28]. In our subgroup analysis of studies using synthetic mesh, mesh placement did not increase SSO requiring reoperation. Overall, synthetic mesh appears to be safer and more effective for emergency laparotomy closure than biologic mesh, especially in clean and clean-contaminated cases.

SSI is a feared complication associated with mesh repair in abdominal surgery, due to the potential for morbidity with mesh infection, mesh explantation, and reoperations [29]. Our study confirms the safety of mesh placement as our analysis found no significant difference in SSI between groups. This result is consistent with the findings of the PROMETHEUS trial, which only included surgeries classified as clean-contaminated and found no significant difference in SSI between the mesh and no mesh groups (4% vs. 5%; $p=0.733$) [8]. However, in contaminated settings, there is conflicting evidence as to whether mesh placement increases infectious complications [30, 31]. For example, a RCT conducted by Ulutas et al. that included contaminated and dirty surgical wounds found no statistically significant difference in SSI rates between the prophylactic mesh group and suture group (14% vs. 11.7%; $p=0.38$). However, they

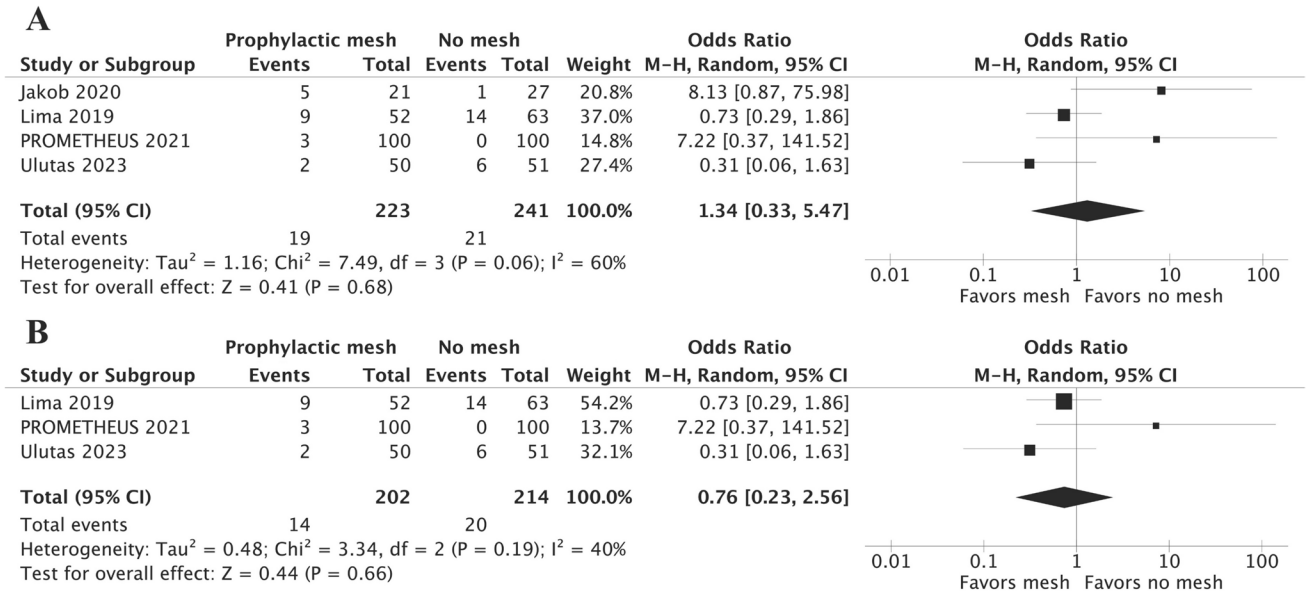

Fig. 9 **A** Forest plot on the incidence of SSOPI after emergency laparotomy. **B** Subgroup analysis of synthetic mesh on incidence of SSOPI after emergency laparotomy

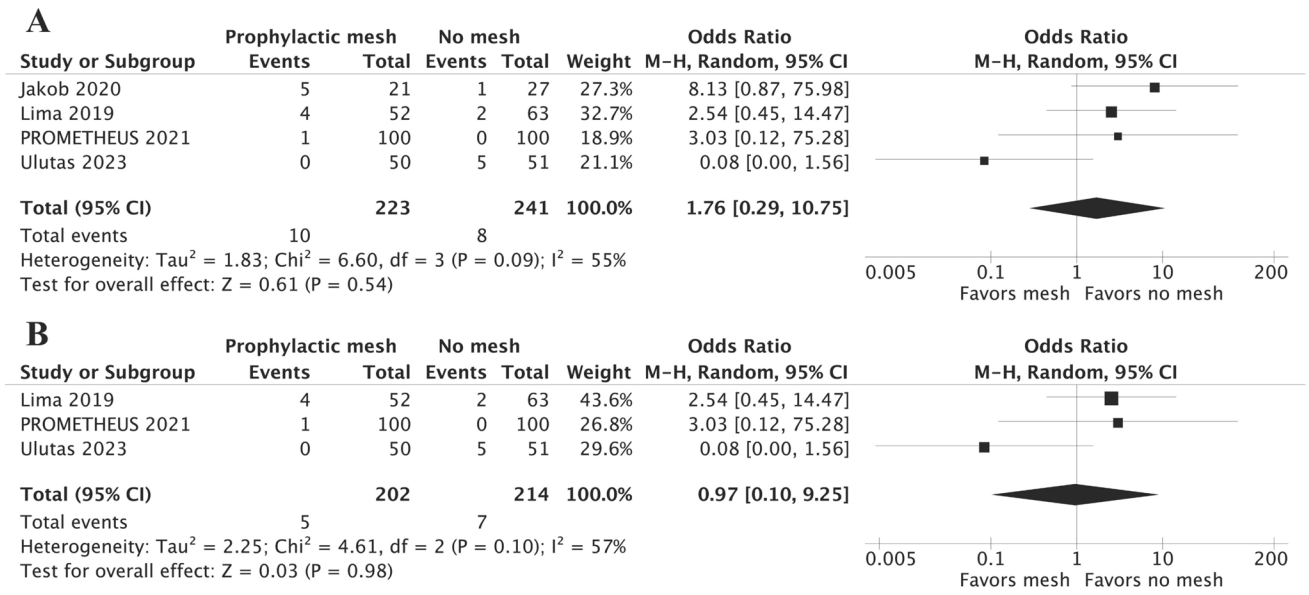

Fig. 10 **A** Forest plot on the incidence of SSO requiring reoperation after emergency laparotomy. **B** Subgroup analysis of synthetic mesh on incidence of SSO requiring reoperation after emergency laparotomy

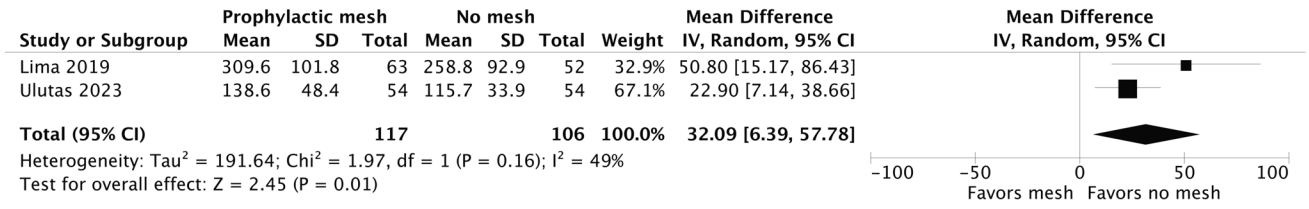

Fig. 11 Forest plot on operative time in emergency laparotomy

did observe an increase in Clavien–Dindo 3A complications in the mesh group, which were treated with bedside interventions and drainage procedures [7]. Understanding the impact of local surgical conditions on infectious risk is essential for the safe and effective implementation of prophylactic mesh augmentation in emergency laparotomy closure. As most patients in our meta-analysis had clean–contaminated wounds, we cannot determine the safety of mesh augmentation in contaminated and dirty cases. The generalizability of our findings to diverse surgical contexts and patients with multiple comorbidities at high infectious risk, especially those involving contaminated or dirty fields, requires further exploration.

Our analysis demonstrated that the use of mesh increased the operative time by an average of 33 min. This finding is consistent with a study by Lima et al. which reported that surgeries with mesh took approximately 50 min longer than those without mesh [17]. The additional steps required for mesh placement and fixation likely contribute to the longer operative time. While longer operative time may be a concern, the potential long-term benefits of mesh placement should be considered when making treatment decisions.

While sublay mesh placement has demonstrated better outcomes for IH repair [32], there is currently no RCT comparing prophylactic mesh locations in emergency laparotomy. In our study, two trials placed the mesh in an onlay position [7, 17], one in an intraperitoneal position [16] and one in a retromuscular position [8]. The PRIMA trial, which compared primary suture repair, sublay mesh, and onlay mesh for elective laparotomy, found that the onlay technique produced superior results [33]. This could be attributed to the technical challenges associated with a sublay repair, which requires greater surgical expertise, especially since laparotomies are often performed by surgeons from varying subspecialties. Also, it is important to preserve the retromuscular space for definitive abdominal wall reconstruction if a hernia were to ultimately occur, as redo retromuscular ventral hernia repairs are extremely challenging cases and associated with significant morbidity [34]. Consequently, the onlay technique could be a more appropriate and feasible option for preventing IHs.

Although mesh augmentation reduces FD and IH in the overall population, this benefit seems to be greater in patients at high-risk for IH, such as patients with abdominal aortic aneurysm and obesity. Patients with abdominal aortic aneurysms are thought to have a connective tissue disorder that makes them more susceptible to developing IH [35, 36]. In the case of obesity, higher intra-abdominal pressure can result in greater tension on the abdominal wall suture, which weakens the wound, impairs collagen synthesis, and increases the risk of infection and IH [37, 38]. Other factors that have a negative impact on wound healing include malignancy, diabetes, steroid use, SSI, smoking, malnutrition, higher ASA score, and older age [25, 39–44]. Among our included studies, Lima et al. and Ulutas et al. included only patients at high-risk for IH, and both studies showed a significant reduction in FD with mesh (0% vs. 13.5% $p=0.003$ and 0% vs. 7.85% $p=0.04$, respectively) [7, 17]. Moreover, the latter also showed a reduction in IH (3.7% vs. 25.9% $p=0.001$) [7]. A cost–utility analysis conducted by Fischer et al. concluded that prophylactic mesh augmentation in high-risk patients is a more effective and less costly option compared to primary suture closure, making it an overall more cost-effective approach [45].

Our study is not without limitations. First, fascial closure technique plays an essential role in preventing FD and IH. Guidelines recommend a continuous small-bite suture technique using a slowly absorbable suture [3]. However, included studies reported different fascial closure techniques, which may have introduced heterogeneity in the results. Second, this study may have underrepresented contaminated or dirty cases, as a majority of the patients included underwent surgery in a clean–contaminated field. This may limit the application of these findings to a broader population, since emergency laparotomies are often performed on contaminated or dirty fields [46]. Also, the availability of data on antibiotic use was limited, with only one study reporting antibiotic prophylaxis. This precluded an evaluation of the potential impact of perioperative antibiotics on the results [7]. Third, only four studies were included in the analysis, which limits the applicability of the findings. Additionally, the studies had a small sample size, and we cannot exclude the possibility that the overall sample size may be underpowered to identify any significant differences in outcomes. Finally, the follow-up period varied among the included studies, which limits our ability to accurately assess the long-term outcomes. Despite these limitations, this review provides valuable insights into the effectiveness and safety of prophylactic mesh augmentation in emergency laparotomy closure. Future studies should aim to include larger samples, particularly in contaminated and dirty surgical fields. Additionally, incorporating cost-effectiveness analysis will help determine the value of mesh placement in emergency laparotomy.

Conclusion

This systematic review and meta-analysis of four studies comprising 464 patients evaluated the effect of prophylactic mesh augmentation on emergency laparotomy closure. The findings suggest that mesh augmentation might lower the incidence of IH, and synthetic mesh might reduce the incidence of FD. Further studies evaluating long-term outcomes and rates of IH are still needed.

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Data availability The authors confirm that the data supporting the findings of this study are available within the article.

Declarations

Conflict of interest All authors declare no conflict of interest.

Ethical approval Due to the nature of this study, it is exempt from the requirement for ethical board registration and individual patient consent.

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