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Prophylactic mesh augmentation in midline laparotomy in elective or emergency settings: a systematic review and network meta-analysis of randomized trials

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Introduction: Incisional hernia (IH) remains a common complication after midline laparotomy. Prophylactic mesh reinforcement reduces IH risk, but the optimal anatomical plane for mesh placement remains uncertain. This systematic review and network meta-analysis (NMA) compared mesh positions for IH prevention while assessing postoperative morbidity.

Methods: A systematic search of PubMed, Embase, and Cochrane databases identified randomized controlled trials (RCTs) comparing prophylactic mesh reinforcement with suture-only fascial closure after laparotomy. The primary outcome was the IH rate. Secondary outcomes were surgical site infection (SSI), surgical site occurrence (SSO), seroma, and hematoma. Pairwise random-effects meta-analysis and frequentist random-effects NMA were performed using risk ratios (RR) with 95% confidence intervals (CI). Treatments were ranked using P-scores.

Results: 27 RCTs, including 4327 patients, were analyzed. The control group was suture-only closure (1891 patients). Mesh positions were onlay (38%), retromuscular/preperitoneal (37%), intraperitoneal (18%), and inlay-strip (7%). Overall, prophylactic mesh reinforcement significantly reduced IH compared with suture-only closure (RR 0.41, 95% CI 0.27–0.62). In the NMA, compared with suture-only closure, onlay mesh reinforcement was associated with the largest relative reduction in IH (RR 0.27, 95% CI 0.17–0.45), followed by retromuscular/preperitoneal (RR 0.42, 95% CI 0.27–0.67). Inlay-strip and intraperitoneal meshes were not significantly superior to suture-only closure. Onlay mesh ranked highest for IH prevention (P-score 0.976). Findings were consistent in the elective and emergency subgroup analyses. For SSI, no mesh position significantly increased the risk compared with the suture-only group. For SSO, onlay mesh reinforcement was associated with a significantly increased risk (RR 1.46, 95% CI 1.03–2.06), whereas retromuscular/preperitoneal was not. Similar results were found for seroma. No mesh position significantly increased the risk of hematoma in the NMA analyses.

Conclusion: Prophylactic mesh reinforcement reduces IH after laparotomy. Both onlay and retromuscular/preperitoneal placement significantly reduced IH. Onlay achieved the highest treatment ranking, without increasing SSI, but at the cost of higher wound morbidity, especially seroma. Further high-quality trials are needed to define the optimal mesh plane, as limited direct evidence between mesh planes precludes firm conclusions of superiority.

KEYWORDS
incisional hernia, laparotomy, network meta-analysis, prophylactic mesh, suture repair

Introduction

Incisional hernia (IH) is a frequent complication after abdominal surgery and remains a major source of post-operative morbidity [1–4]. The incidence ranges from 5%–20% after laparotomy to approximately 1.7%–24.3% after laparoscopic procedures [4, 5]. Incidence can reach 30% in high-risk settings [1, 4]. IH commonly occurs after vascular, colorectal, bariatric, and upper gastrointestinal surgery [6]. Several patient- and procedure-related risk factors have been identified, including chronic diseases, obesity, emergency surgery, midline incision, and infection [7–9]. IH may present with chronic symptoms such as an abdominal bulge or discomfort, but may also lead to small or large bowel obstruction [4]. Diagnosis is primarily clinical, with the addition of ultrasound and CT scan to confirm the defect [10]. Several classification systems have been described, with the European Hernia Society classification for IH published in 2009 being the most widely used [11]. Management can either consist of a watchful waiting therapy or a surgical repair with fascial closure and reinforcement with a mesh [12]. The cost of IH repair was estimated at $15,899 per case in 2006 [13]. Although surgery for IH is nowadays well-established, prevention has become a major focus in recent years [1]. Prophylactic mesh reinforcement instead of abdominal closure by conventional suture-only has been proposed as a strategy to reduce the risk of IH [3]. Even if the small-bite suture technique is necessary to decrease the rate of IH, it is not sufficient, as the long-term follow-up of the STITCH-it trial revealed that 34% of patients still developed an incisional hernia [14]. Initially, the use of prophylactic mesh reinforcement was studied in patients undergoing open abdominal aortic aneurysm repair, followed by bariatric surgery, and finally colorectal and upper gastrointestinal surgery, including randomized controlled trials (RCTs) [2]. Growing evidence suggests that prophylactic mesh reinforcement significantly reduces the incidence of IH [2]. Several anatomical planes can be used to place a mesh (onlay, retromuscular, intraperitoneal); however, the optimal anatomical plane to prevent IH without increasing surgical site infection (SSI) or occurrence (SSO) remains a topic of ongoing debate [1, 3]. Therefore, this network meta-analysis (NMA) compares anatomical positions for prophylactic mesh reinforcement in elective and emergency settings to compare their relative efficacy and morbidity profiles.

Materials and methods

Data sources and search strategy

This systematic review and NMA was conducted in accordance with the PRISMA guidelines [15]. This review was registered in PROSPERO with the number CRD420261293774. The research question and inclusion and exclusion criteria were defined according to the PICOS framework shown in Table 1. The primary endpoint was the occurrence of IH after laparotomy. Secondary endpoints were SSI, SSO, seroma, hematoma, and mortality rates after prophylactic mesh reinforcement versus conventional suture alone. Systematic research of PubMed, Embase, and the Cochrane database was performed to identify RCTs comparing prophylactic mesh reinforcement with conventional suture alone after laparotomy, without date restrictions. Search terms combined keywords related to IH prevention using Boolean operators. The search strategy is available in Supplementary Appendix 1.

Only studies published in English were included. Language selection filters were applied directly to the databases. The literature search was limited to RCTs. Meta-analyses, systematic reviews, retrospective studies, and prospective trials without randomization were excluded. All identified records were imported into an Excel database (Microsoft Office) for screening.

Study selection

Two reviewers screened titles and abstracts for relevance and eligibility. Duplicates were removed before screening. The remaining articles were reviewed based on their abstracts for relevance, in accordance with the inclusion and exclusion criteria. Disagreements between reviewers during screening or full-text assessment were solved by discussion. Articles meeting all the search criteria were kept for analysis. A PRISMA flowchart diagram depicting the selection process is available in Figure 1.

Data extraction

Two reviewers extracted data using a standardized Excel spreadsheet (Microsoft Office). Included variables were (i) intervention type, (ii) emergency or elective operation, (iii) number of randomized and analyzed patients, (iv) length of follow-up, (v) number lost to follow-up, (vi) number of patients assigned to each therapy, (vii) baseline characteristics, (viii) suture technique, (ix) suture type, (x) suture wound to length ratio, (xi) incisional hernia rate, (xii) SSI rate, (xiii) SSO rate, (xiv) hematoma rate, (xv) seroma rate, and (xvi) mortality rate. Missing data were excluded from the statistical analysis.

In cases where multiple publications reported outcomes from the same study cohort at different follow-up periods, post-operative complications (SSI, SSO, hematoma, seroma) were extracted from the earliest report, whereas IH incidence was extracted from the publication reporting the longest available follow-up.

Risk of bias assessment

The risk of bias in the present study was assessed using the Cochrane Risk Of Bias 2 (ROB-2) tool for RCTs [16]. Two reviewers independently reviewed each study and scored each RCT.

Data synthesis and analysis

Statistical analyses were performed in R (version 4.5.0) using the *meta* and *netmeta* packages. Effect sizes were expressed as risk ratios

Abbreviations: IH, incisional hernia; RCT, randomized controlled trial; SSI, surgical site infection; SSO, surgical site occurrence; NMA, network meta-analysis; RR, risk ratio; CI, confidence intervals.

TABLE 1 PICOS criteria.

Network meta-analysis on prophylactic mesh reinforcement	
The patients (P) of interest were:	Patients with midline laparotomy
The interventions (I) of interest were:	mesh reinforcement (onlay, retromuscular, intraperitoneal, inlay)
The comparisons (C) of interest were:	Conventional suture without mesh
The outcomes (O) of interest were:	Incisional hernia, SSI/SSO, hematoma and seroma rate
The study types (S) of interest were:	RCT

(RR) with 95% confidence intervals (CI). Pairwise meta-analyses were conducted using random-effects models. The I^2 statistic test assessed heterogeneity. Results were presented using forest plots. A frequentist NMA was performed using the *netmeta* package to combine direct and indirect evidence across multiple interventions. For the primary NMA, retromuscular and preperitoneal planes were combined into a single posterior-plane node to preserve network connectivity and statistical power. A sensitivity analysis separating these anatomically distinct planes was performed. A random-effects model assuming a common heterogeneity was used. Consistency between direct and indirect evidence was assessed at global and local levels. Global inconsistency was evaluated using the design-by-treatment interaction model (global inconsistency), while local inconsistency was explored using node-splitting analysis. Treatment ranking was performed using P-scores. Results were presented using forest plots, network diagrams, and a P-score heatmap. The certainty of evidence was not formally assessed using CINeMA. Confidence in the network estimates is instead discussed narratively in the discussion. A two-sided p-value <0.05 was considered statistically significant. Multi-arm trials were analyzed using a pairwise strategy and *the netmeta* functions, which account for common comparators in the statistical analysis, thereby avoiding unit-of-analysis errors and double counting.

This study is a systematic review and network meta-analysis of previously published de-identified aggregate data. As no new research on humans or animals was performed, ethical approval and informed consent were not required.

Results

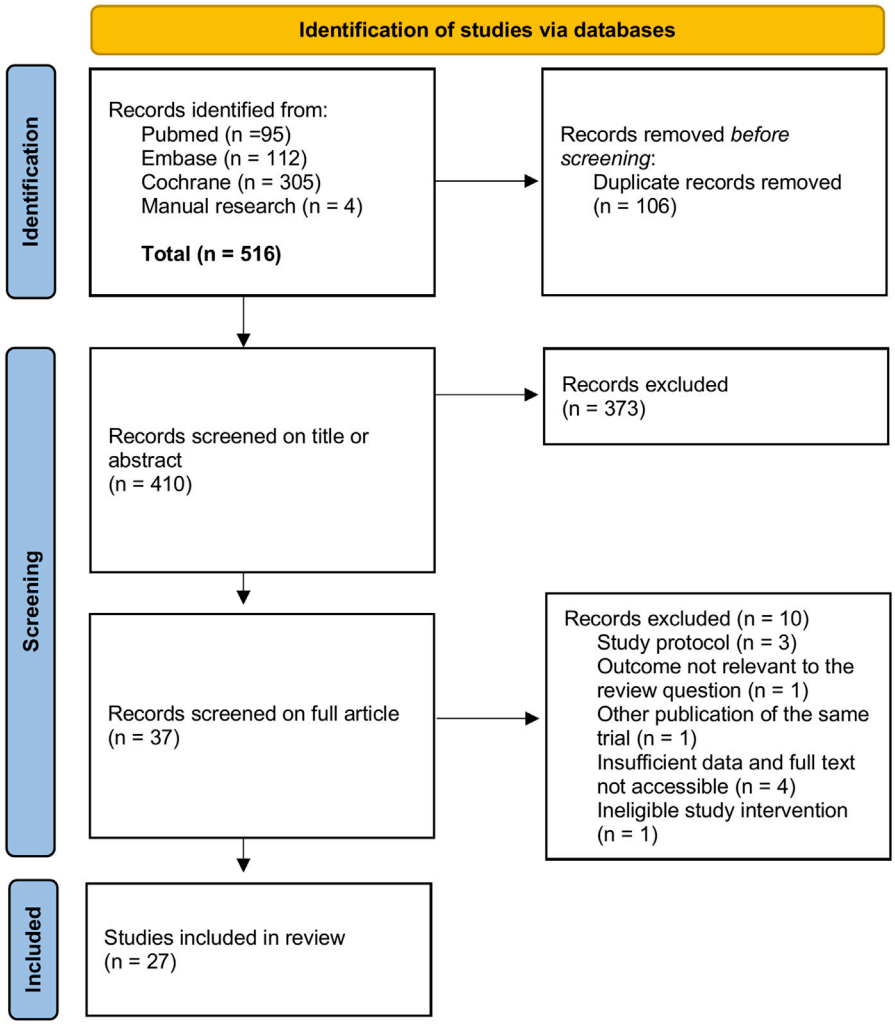
27 RCTs [17–43] were included in the analysis. Among them, 23 RCTs (85%) were primary index publications and 4 (15%) were follow-up reports. 24 studies (89%) had a two-arm design, and 3 (11%) were three-arm comparisons. According to the Cochrane Risk Of Bias 2 (ROB-2) tool for RCTs, 15% of studies were judged to be at low risk of bias, 74% raised some concerns, and 11% were considered at high risk of bias. Included studies involved colorectal surgery (4%), Upper-GI/bariatric surgery (15%), vascular surgery (19%), and mixed surgical populations (63%). Procedures were elective (74%), emergency (15%), and mixed (11%). A total of 4327 patients were analyzed, with a median follow-up of 24 months. Of these, 1891 patients were allocated to the suture-only group, and 2436 to the prophylactic mesh group. In the suture group, fascial closure was achieved with interrupted suture (7%), continuous small-bite (14%), and continuous large-bite (79%). Suture materials were non-absorbable (20%), quickly absorbable (8%), and slowly absorbable (72%). In the mesh group, mesh placements were onlay (38%), inlay-strip (7%), retromuscular/preperitoneal (37%), and intraperitoneal (18%). Inlay-strip consisted of the interposition of a mesh between the right and left fascia, which were all closed together. Meshes were absorbable in 23% and non-absorbable in 77%. A summary of the included studies is available in Supplementary Appendix 2.

Incisional hernia

22 RCTs were included for analysis. In conventional pairwise meta-analysis, prophylactic mesh reinforcement significantly reduced the risk of IH compared with suture-only closure (RR 0.41, 95% CI 0.27–0.62), although a substantial heterogeneity was observed (I^2 = 69.5%). These results are shown in Figure 2.

On the overall frequentist NMA, no global inconsistency (p-value = 0.245) or local inconsistency was noted. All analyses of global and local inconsistency are available in Supplementary Appendix 3. Compared with suture-only closure, onlay mesh showed the largest relative reduction of IH risk (RR 0.27, 95% CI 0.17–0.45), followed by retromuscular/preperitoneal mesh (RR 0.42, 95% CI 0.27–0.67). Inlay-strip mesh and intraperitoneal mesh showed no significant reductions in IH risk respectively (RR 1.18, 95% CI 0.47-2.96; RR 0.64, 95% CI 0.36–1.13). These results are shown in Figure 3. A sensitivity analysis was performed for IH prevention, where retromuscular and preperitoneal were separated. Both planes remained associated with a significant decrease in IH risk. Results of the sensitivity analysis are available in Supplementary Appendix 4. Rankings analysis identified onlay mesh as the highest-ranked technique (P-score 0.976), followed by retromuscular/preperitoneal (P-score 0.729). The node-network model of IH is shown in Figure 4. The network was predominantly based on studies comparing mesh reinforcement with suture-only closure, with only two studies providing direct evidence between onlay and retromuscular/preperitoneal placement. Other between-mesh comparisons relied on indirect evidence. A similar network geometry was observed for all secondary outcomes.

In the elective subgroup analysis, no global inconsistency was detected (p-value 0.348). Onlay mesh remained the highest-ranked technique (RR 0.31, 95% CI 0.19–0.52), followed by retromuscular/preperitoneal (RR 0.47, 95% CI 0.30–0.75). P-score rankings confirmed onlay mesh as the highest-ranked option (P-score 0.961), followed by retromuscular/preperitoneal (P-score 0.688). In the emergency surgery subgroup, global and local inconsistency were not available due to the presence of a star-shaped network. Onlay (RR 0.12, 95% CI 0.03–0.43) and retromuscular/preperitoneal (RR 0.28, 95% CI 0.12–0.66) showed a statistically significant reduction of IH after mesh reinforcement, whereas intraperitoneal mesh showed no benefit (RR 3.86, 95% CI 0.43–34.47). Onlay mesh ranked the highest (P-score 0.952), followed by retromuscular/preperitoneal (P-score 0.708).



Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

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FIGURE 1
PRISMA flow diagram.

According to the mesh material, non-absorbable mesh was associated with significant global inconsistency (p-value 0.0484), although no local inconsistency was identified. Within this subgroup, onlay (RR 0.28, 95% CI 0.17–0.47), retromuscular/preperitoneal (RR 0.30, 95% CI 0.18–0.52), and intraperitoneal (RR 0.46, 95% CI 0.22–0.94) were all superior to suture-only, with onlay mesh ranked first (P-score 0.813). In the absorbable mesh subgroup, global and local inconsistencies were unavailable due to the presence of a star-shaped network. Only onlay mesh significantly reduced the risk of IH (RR 0.13, 95% CI 0.04–0.46), whereas retromuscular/preperitoneal (RR 0.88, 95% CI 0.60–1.28), inlay-strip (RR 1.18, 95% CI 0.85–1.63), or intraperitoneal (RR 0.85, 95% CI 0.57–1.25) showed no clear benefit. Onlay ranked highest among the absorbable mesh subgroup (P-score 0.998).

SSI

21 RCTs were included for analysis. In conventional pairwise meta-analysis, no significant increase in SSI was noted after mesh reinforcement compared with suture-only (RR 1.23, 95% CI 0.87–1.72), with moderate heterogeneity (I^2 = 32.9%). In NMA, no evidence of global inconsistency (p-value 0.379) or local inconsistency was detected. No mesh position differed significantly from suture-only with respect to SSI risk. These results are shown in Figure 5. Ranking probabilities suggested intraperitoneal mesh as the most favorable strategy (P-score 0.780), followed by suture-only (P-score 0.690), retromuscular/preperitoneal (P-score 0.539), and then onlay mesh (P-score 0.295). Subgroup analyses yielded similar neutral results, irrespective of surgical settings or mesh type.

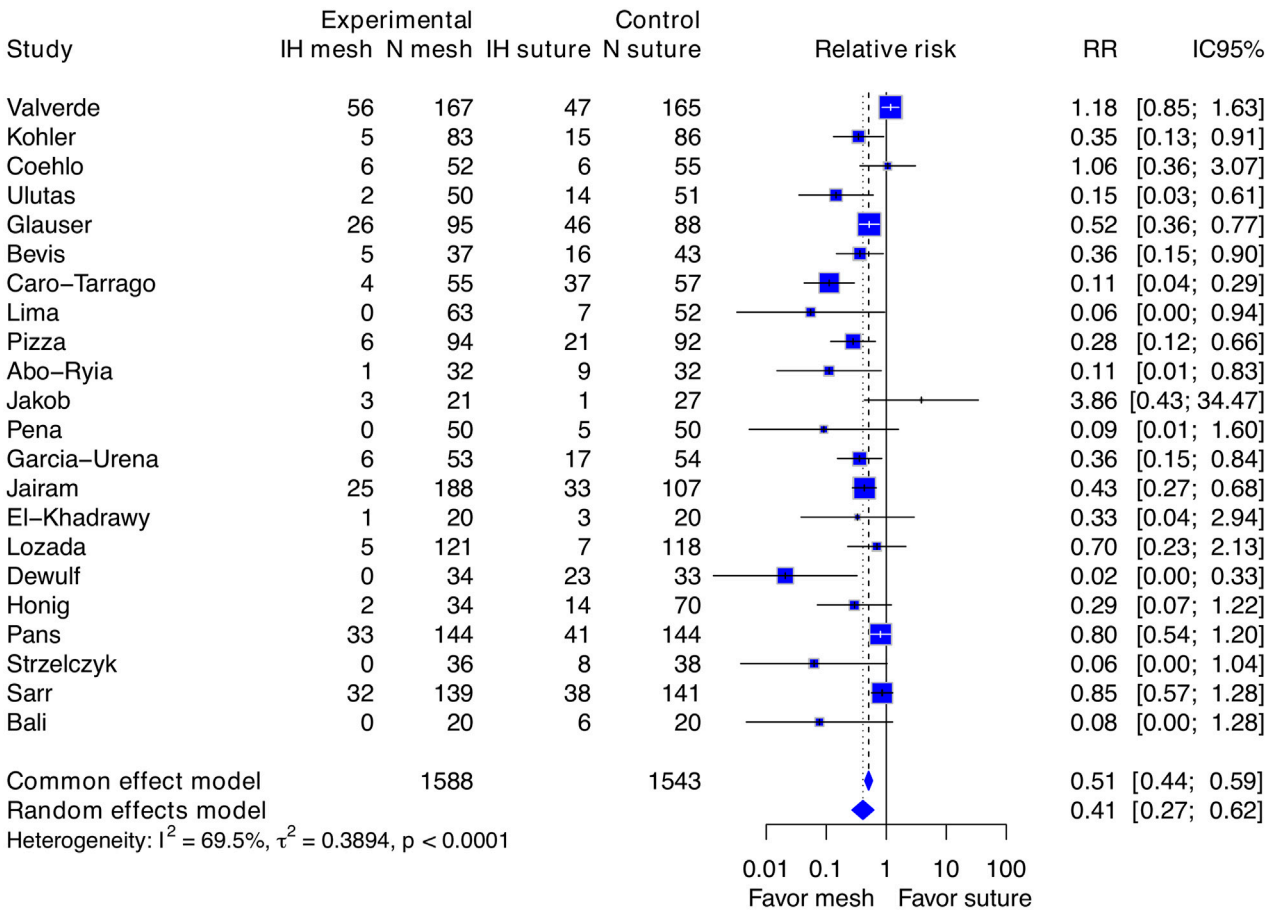


FIGURE 2
Pairwise meta-analysis comparing mesh reinforcement vs. suture-only for IH prevention.

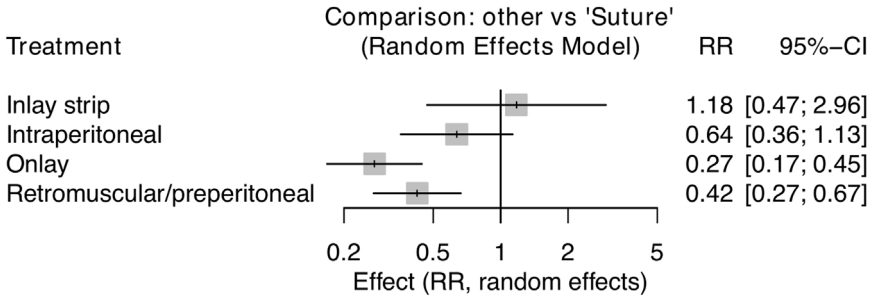


FIGURE 3
Forest plot of IH rate after mesh reinforcement vs. suture-only.

SSO

22 RCTs were included for analysis. In conventional pairwise meta-analysis, mesh reinforcement was associated with a statistically significant increase in SSO compared with suture-only (RR 1.38, 95% CI 1.06–1.79), with moderate heterogeneity (I^2 = 54.2%). In NMA, the analysis showed evidence of global inconsistency (p-value = 0.012) but not local inconsistency among the studied interventions. Compared with suture-only closure, onlay mesh was associated with a significant increase in SSO (RR 1.46, 95% CI 1.03–2.06), whereas the other mesh positions were not. These results are shown in Figure 6. Ranking probabilities showed suture-only was linked with the lowest risk of SSO (P-score 0.818), followed by intraperitoneal (P-score 0.782), retromuscular/preperitoneal (P-score 0.396), and finally onlay mesh (P-score 0.304).

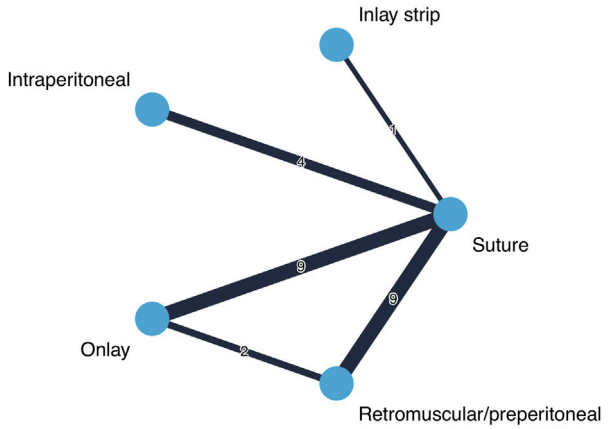


FIGURE 4
Node-network model on studies for IH rate after mesh reinforcement vs. suture-only.

In the elective subgroup analysis, global inconsistency was present (p-value 0.027), but no local inconsistency was noted between interventions. NMA elective analysis revealed similar neutral results, except for an increased risk of SSO, mostly linked with onlay mesh placement (RR 1.56, 95% CI 1.01–2.41). In the emergency surgery subgroup, global and local inconsistencies were unavailable. No statistically significant increase in SSO was noted in emergency settings for onlay mesh (RR 1.22, 95% CI 0.68–2.18), or retromuscular/preperitoneal (RR 1.40, 95% CI 0.68–2.88). Results from the NMA analysis of absorbable and non-absorbable mesh are available in Supplementary Appendix 5.

Seroma

18 RCTs were included for analysis. In conventional pairwise meta-analysis, mesh reinforcement was associated with a statistically significant increase in seroma compared with suture-only (RR 2.09, 95% CI 1.51–2.90), with no evidence of between-study heterogeneity (I^2 = 0.0%). For NMA analysis, no global inconsistency (p-value 0.175) or local inconsistency were detected. Onlay mesh was associated with a statistically significant increase in seroma risk (RR 2.53, 95% CI 1.70–3.78), whereas retromuscular/preperitoneal was not (RR 1.42, 95% CI 0.87–2.32). Similar results were found for the elective, emergency, and non-absorbable subgroups. This tendency was not confirmed in the absorbable mesh group, where onlay mesh was not statistically associated with an increased risk of seroma (RR 2.03, 95% CI 0.53–7.78).

Hematoma

12 RCTs were included for analysis. In conventional pairwise meta-analysis, mesh reinforcement was associated with a statistically significant increase in hematoma compared with suture-only (RR 1.69, 95% CI 1.05–2.71), with no evidence of between-study heterogeneity (I^2 = 0.0%). In NMA, the analysis showed no evidence of global inconsistency (p-value = 0.385) or local inconsistency among the interventions studied. No mesh placement was statistically linked with an increased risk of hematoma. Detailed subgroup analysis is available in Supplementary Appendix 6.

Discussion

This systematic review and network meta-analysis assesses the effectiveness of prophylactic mesh reinforcement after midline laparotomy compared with suture-only fascial closure in both elective and emergency surgeries. In addition, the NMA enabled indirect comparisons between mesh positions to assess which anatomical plane may provide the most favorable balance between efficacy and morbidity. To our knowledge, this is the largest NMA on this topic to date, including 27 RCTs and 4327 patients. This study extends the previous NMA by Tansawet et al. (2020), which included 20 RCTs until 2019 [4]. They found that onlay mesh and retromuscular prophylactic augmentation were effective for preventing IH. In contrast, the present study incorporates a larger cohort of patients, more recent publications, an emergency surgery population, and an additional analysis of wound morbidity comparing the risk of SSO and seroma. Our analyses provide a more comprehensive and clinically relevant assessment of prophylactic mesh reinforcement in the current surgical practice.

Regarding IH prevention, this study supports prophylactic mesh reinforcement after a midline laparotomy compared with suture-only. The benefit is verified through multiple RCTs and MAs [1–4].

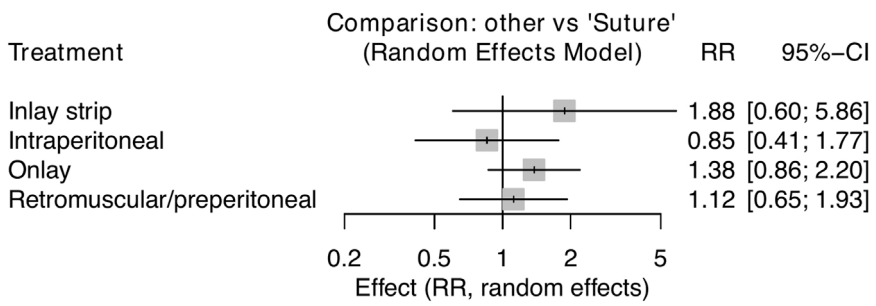


FIGURE 5
Forest plot of SSI rate after mesh reinforcement vs. suture-only.

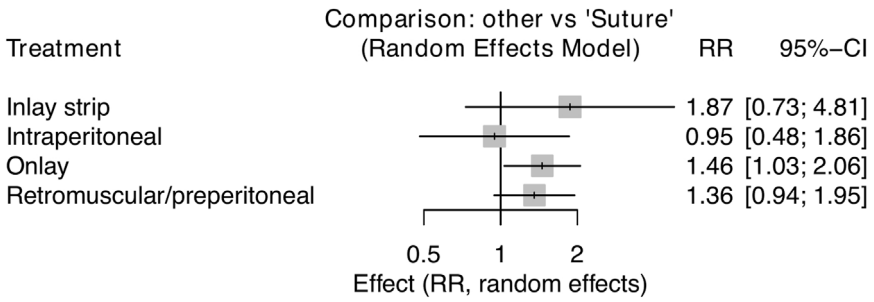


FIGURE 6
Forest plot of SSO rate after mesh reinforcement vs. suture-only.

Guidelines from the European Hernia Society in 2022 already suggested that prophylactic mesh reinforcement should be considered for elective laparotomy [44]. However, uncertainty has persisted regarding the optimal anatomical plane for mesh placement. A recent meta-analysis by Lagger et al. found a significant decrease in IH with the use of retromuscular prophylactic mesh reinforcement in elective settings [45]. The I-PREVENT-AAA trial also described that retromuscular and onlay prophylactic mesh were effective for incisional hernia prevention [46]. In our study, both onlay and retromuscular/preperitoneal reinforcement were associated with a significant reduction of IH. Although onlay mesh achieved the highest P-score for IH prevention, this ranking should not be over-interpreted as definitive evidence of superiority over other mesh positions. Considering the heterogeneity of the included studies and the indirect nature of several comparisons, onlay mesh may represent an appropriate option for prophylactic mesh reinforcement in both elective and emergency settings, even if emergency NMA should be interpreted with caution, given the star-shaped network model and the inability to assess local inconsistency. These results are encouraging from a clinical perspective, as onlay mesh reinforcement offers several practical advantages. Technically the onlay mesh placement is a relatively easy and rapid intervention and it has the advantage to leave the retromuscular plane intact for further incisional repair should one occur. While the retromuscular mesh placement offers an excellent anatomical position used by many abdominal wall surgeons to repair incisional hernia, it requires greater expertise, involves a learning curve and more extensive dissection, with potential risks of peritoneal breach, bleeding, or injury to the neurovascular structures [44, 47, 48]. This complexity cannot be performed without prolonging the ongoing surgical procedure, without a formal teaching or a dedicated surgical team to close the abdominal wall. Although the present NMA did not assess operative time, cost, or resource utilization, these technical differences may influence the reproducibility and feasibility of prophylactic mesh reinforcement in routine surgical practice.

The occurrence of SSI remains one of the principal concerns limiting wider adoption of mesh prophylaxis among surgeons. However, several previous meta-analyses demonstrated no significant increase in SSI after mesh reinforcement [1, 3, 4]. Our study confirms these findings, as no statistically significant increase in SSI was noted after onlay mesh or retromuscular/preperitoneal mesh reinforcement. Altogether, these data suggest that mesh reinforcement is a safe and effective technique for IH prevention without significantly increasing SSI.

SSO remains another important consideration after prophylactic mesh implantation, although not all anatomical planes appear to have the same risk profile. In our study, pairwise MA showed a significant increase in SSO following mesh reinforcement compared with suture-only. NMA further identified onlay mesh as the principal risk factor for SSO, particularly in elective settings, whereas this risk was not confirmed in emergency surgeries. These results, nevertheless, should be interpreted with caution as the network model showed global inconsistency, showing disagreement between direct and indirect evidence. This could be explained in part by the heterogeneous definition of the SSO across the different studies, leading to the global inconsistency observed in the SSO network. Regarding seroma, the association between seroma and onlay mesh appeared more robust, as no global or local inconsistencies were detected. To date, the literature has reported conflicting results, with studies reporting higher seroma rates after onlay mesh reinforcement, while others have found no significant differences [1, 3, 4].

Our data suggest that onlay prophylactic mesh reinforcement provides an effective strategy for IH prevention without a significant increase in the SSI rate, but at the cost of increased wound morbidity, primarily due to seroma formation. This is probably linked to an extensive dissection of the subcutaneous space, leaving space for the development of a seroma, as mentioned in some studies [49]. Interestingly, the use of absorbable mesh did not statistically increase the risk of SSO. Further studies are needed to clarify the impact of the type and the size of onlay mesh reinforcement on SSO incidence.

A major strength of the present study is the use of RCTs only to reduce selection bias and inclusion of emergency surgeries. The use of NMA analysis further enabled statistical comparison and ranking of the different anatomical planes of mesh placement, providing insights beyond those achievable with conventional pairwise MA alone. Finally, for the vast majority of primary and secondary outcomes, no significant global or local inconsistency was detected, supporting the overall robustness of the network estimates.

Mortality was listed as a secondary outcome. However, reporting was inconsistent across RCTs and was not meaningful for a statistical analysis.

Several limitations should also be acknowledged. Clinical heterogeneity was present among the included studies, with a mixed population undergoing vascular, bariatric, and colorectal surgeries. Heterogeneity also existed in surgical indications, mesh materials, follow-up duration, and baseline IH risk. The substantial heterogeneity observed in the pairwise meta-analysis of IH (I^2 = 69.5%) could be explained by differences in surgical population, baseline IH risk, closure technique, mesh characteristics, and follow-up duration. Meta-regression to further explore these potential sources of heterogeneity was not performed because of the limited number of studies within individual covariate categories. Variability in closure techniques was also identified, as most suture-only closures were performed with continuous large-bite, in contradiction with the recent guidelines advocating small-bite closures. This may have resulted in higher baseline IH rates in the control group and could have amplified the apparent benefit of prophylactic mesh reinforcement. As a substantial proportion of the evidence supporting prophylactic mesh reinforcement derives from trials using large-bite closure, which no longer represents the current standard of care, the magnitude of the observed benefit may not be directly transferable to contemporary clinical practice using small-bite closure. Differences in mesh materials, size, weight, pore size and fixation techniques may have influenced both efficacy and morbidity outcomes, thereby limiting comparisons between studies. Variation in follow-up duration may also have influenced IH detection, as longer follow-up provided more opportunity to identify late-occurring hernias. Clinical heterogeneity may also challenge the transitivity assumption underlying the NMA. Potential effect modifiers differed across trials, including surgical setting and indication, contamination status, baseline IH risk and obesity prevalence, mesh characteristics and fascial closure technique. These differences could influence relative treatment effects and, therefore, the validity of indirect comparisons. Additional heterogeneity was related to outcome definitions, particularly for endpoints such as SSO or seroma, which were not uniformly reported across trials. Most included studies were judged to raise some concerns according to the Cochrane ROB-2 tool, while only a minority were considered at low risk of bias. Furthermore, some network comparisons demonstrated significant global inconsistency, notably for SSO, and local inconsistency could not always be assessed because of a star-shaped network configuration with few direct head-to-head trials between mesh planes. Therefore, several estimates should be interpreted with appropriate caution. Treatment rankings based on P-score should also be interpreted cautiously, as statistical rankings do not equal clinical superiority. The certainty of evidence was not formally assessed using CINeMA, which represents another limitation. Confidence in the network estimates likely varies across outcomes. For IH, the absence of global or local inconsistency supports the consistency of the network estimates. However, substantial heterogeneity, limited direct evidence, and small sample sizes in some treatment nodes warrant caution. Confidence is lower for outcomes such as SSO, for which significant global inconsistency was detected, and for subgroup analyses based on sparse or star-shaped networks. These limitations should be considered when interpreting treatment effects and rankings.

Interpretation of the inlay node also warrants caution. Only one RCT contributed to this analysis, and the surgical technique did not represent a conventional inlay mesh reinforcement. Instead, a narrow mesh strip was incorporated within the suture, acting as a reinforced suture rather than a true bridge.

Another potential limitation is the decision to combine retromuscular and preperitoneal mesh placements into a single anatomical group. Retromuscular and preperitoneal planes are anatomically and biologically different. These differences imply distinct tissue interfaces and technical requirements for dissection and mesh placement. Therefore, these two approaches should not necessarily be considered biologically or technically interchangeable, and combining them into a single node may have obscured potential differences in efficacy or morbidity. A sensitivity analysis separating retromuscular (8 studies) and preperitoneal (4 studies) was performed. Both planes remained associated with a significant reduction in IH risk, especially preperitoneal, with results comparable to onlay mesh. However, this node included only 112 patients, compared with 745 for the retromuscular node and 926 for the onlay mesh node. Moreover, estimates for secondary outcomes became less precise, with wider confidence intervals, and no emergency surgery study evaluated preperitoneal placement. Therefore, we grouped the retromuscular and preperitoneal planes as a common posterior plane for primary analysis, as separating these planes into two groups would have substantially fragmented the available evidence. Moreover, given the limited number of RCTs, constructing a meaningful network model, especially for subgroup analysis (emergency vs. elective surgery), would have been compromised.

In conclusion, prophylactic mesh reinforcement effectively prevents incisional hernia after midline laparotomy in both elective and emergency settings, without increasing surgical site infection. Both onlay and retromuscular/preperitoneal placement reduced IH risk. Onlay achieved the highest treatment ranking but should not be regarded as definitively superior, given the heterogeneity and the limited direct evidence between planes. Its practical advantages—technical simplicity and preservation of the retromuscular plane for future repair—make it an appropriate option, at the cost of higher seroma rates. Further high-quality randomized trials are needed to define the optimal mesh plane for prophylactic reinforcement.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The datasets analyzed in the current study are available from the corresponding author upon request. Requests to access these datasets should be directed to timothee.girardin@gmail.com.

Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study

was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements.

Author contributions

TG and M-OS contributed to the conception and design of the study, literature screening, data extraction, data interpretation, and manuscript revision. TG performed the statistical analyses and drafted the manuscript. All authors contributed to the article and approved the submitted version.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontierspartnerships.org/articles/10.3389/jaws.2026.17385/full#supplementary-material

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