Hernia (2025) 29:147
https://doi.org/10.1007/s10029-025-03314-x

REVIEW

The safety of polypropylene mesh in repairing incarcerated or strangulated hernias with organ resection

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Received: 14 January 2025 / Accepted: 3 March 2025

Abstract

Background Organ resection is often required in incarcerated or strangulated hernias, which makes the surgical field more contaminated, and increased contamination makes it possible to elevate the risk of surgical site infections and increase the likelihood of hernia recurrence. The safety of polypropylene mesh for repair in such contaminated conditions is equivocal, leading to controversy concerning its application. This study aims to elucidate this matter by comparing the complications between mesh repair and primary repair specifically in strangulated or incarcerated hernias with organ resection. At the same time, the study contributed to assessing the safety of polypropylene mesh in repairing hernias under conditions where infection is a significant concern.

Methods This meta-analysis was reported following PRISMA 2020 guidelines, all studies were searched and retrieved from major databases (PubMed, and Web of Science), and were included if they reported complications between mesh repair and primary repair in incarcerated or strangulated ventral or groin hernias with or without organ resection. Meta-analyses were conducted when possible, and subgroup analyses were made for the severity of complications (major vs minor) and hernia type (ventral vs. groin). According to the study design, the risk of bias was assessed using the Newcastle–Ottawa Scale. All related articles and reference lists in these original studies were also obtained from the above databases.

Results Nine observational studies containing 1287 patients with incarcerated or strangulated hernias were included. Three findings were found: (1) Overall complications in the mesh repair group were more than those in the primary repair group in incarcerated or strangulated hernias with organ resection (OR = 4.93; 95% CI: 2.54, 9.56; P < 0.00001). (2) There was a slight tendency for more complications to occur in the organ resection group than in the non-resection group with mesh repair, although the difference was subtle (OR = 3.36; 95% CI: 0.86, 13.15; P = 0.08). (3) There was a trend that more complications occurred when mesh was used in emergent ventral hernia repair than in primary repair (OR = 3.33; 95% CI: 0.91, 12.26; P = 0.07), while, this trend was not observed in emergent groin hernia repair.

Conclusion In cases of incarcerated or strangulated hernias requiring organ resection, the use of polypropylene mesh has been correlated with a higher incidence of complications compared to primary repair. Additionally, a trend was observed toward greater complication rates when ventral hernia repair was performed. Therefore, polypropylene mesh should be used cautiously in strangulated hernias with organ resection or in the repair of the ventral hernia.

Keywords Hernia repair · Incarceration · Strangulation · Organ resection · Polypropylene mesh · Complication

Introduction

At present, the incarcerated hernia is a common cause of emergency surgical interventions [1], which is associated with a higher complication rate compared to non-incarcerated hernias [2]. Resulting of the absence of blood flow to the entrapped internal organs, incarcerated hernias can easily progress to strangulation hernias [3]. With the development of organ necrosis, the surgical site can evolve into cellulitis, characterized by substantial infection [4].

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Published online: 22 April 2025

Historically, strangulated hernias have been considered an absolute contraindication for the use of artificial mesh [5], likely due to the increased contamination of the surgical field which can elevate the risk of postoperative surgical site infections (SSIs) and hernia recurrence [6]. Therefore, synthetic mesh should be used with caution in strangulated hernias. However, current studies have demonstrated that incarcerated and strangulated hernia repair might be safely performed using artificial mesh [7, 8]. Additionally, other research groups have demonstrated that incarcerated and strangulated hernias could be effectively repaired using artificial mesh [9].

Furthermore, strangulated hernias requiring bowel resection where the potential contamination risk exists, are associated with a significantly elevated risk of postoperative surgical site infections (SSIs) [10, 11]. At the same time, some studies have proven that the use of polypropylene mesh in hernia repair surgeries with potential contamination can increase the incidence of postoperative complications [12]. However, the use of synthetic mesh soaked in antibiotic solution has been demonstrated to possess potential advantages in reducing infection rates, especially in contaminated settings [13]. Consequently, a debate on the utility of prosthetic grafts when requiring organ resection still exists [14].

Currently, the types of postoperative complications following polypropylene mesh repair in emergency cases differ between inguinal hernias and ventral hernias, since they are pathologies that behave differently. Complications such as infection, chronic pain, mesh erosion, and migration are relatively common in ventral hernias [15], while complications such as infection and sexual dysfunction more easily occur in inguinal hernias [6], therefore, it is necessary to select similar complications as outcomes measures when analyzing the efficacy of synthetic mesh in emergencies for both ventral and inguinal hernias. Additionally, numerous risk factors that need to be considered in the use of mesh, have been identified in incarcerated or strangulated hernias that can influence the assessment of postoperative outcomes following synthetic mesh repair, which may vary depending on the type of hernia. For example, in ventral hernias, in addition to enterotomy and contamination of the surgical field, other factors such as prior hernia repair, abdominal skin or wound issues, obesity, poorly controlled diabetes, active smoking, and the large size of the defect have been found to increase the rate of complications [16–20]. In inguinal hernias, risk factors such as the importance of the degree of contamination of the surgical site, patient age, ASA score, diabetes, smoking, mode of admission (emergency vs. elective surgery), type of anesthesia, bilateral and sliding hernias would be highlighted, which should be seriously considered in the use of synthetic mesh [21]. Thus, subgroup analysis of similar complications between ventral and groin hernias has been proven necessary in exploring the safety of mesh use in emergencies.

This study aims to evaluate the safety of mesh repair in incarcerated or strangulated hernias with organ resection, to furnish surgeons with evidence-based recommendations on the rational use of polypropylene mesh in these complex surgical situations.

Methods

Search strategy

The strategy for establishing the evidence base for the assessment of the complications of mesh repair and primary repair in incarcerated or strangulated hernias with organ resection was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [22]. This study has been registered in the PROSPERO database with the registration number 652349.

Studies that compared the complications of mesh repair and primary repair in incarcerated or strangulated hernias with organ resection were searched and identified from major databases including PubMed, and Web of Science. The following index terms were used for searching and retrieving related articles: “Mesh”, “Bowel resection”, “Omentectomy”, “Incarcerated or strangulated hernia”, “Ventral hernia”, and “Groin hernia”. For the study selection process, Articles that were not related and not eligible were removed, followed by three authors independently screening and identifying full-text articles retrieved, any discrepancy was resolved within the author group, and agreement was obtained. Local ethical approval was not required for this type of study. No funding was available.

Inclusion criteria and exclusion criteria

We included all patients with incarcerated or strangulated ventral and groin hernias who had undergone synthetic mesh repair or primary repair with or without organ resection. Studies on parastomal hernias and biological mesh were excluded. The outcome measures assessed were the complications of incarcerated or strangulated hernia repair with or without organ resection, analyzed for mesh repair and primary repair separately. Studies not specifying procedure type (mesh or primary) were excluded. At the same time, we excluded studies that were not conducted for follow-up after the patients were discharged from the hospital. Studies that did not require control groups were excluded. Observational comparing studies, case–control studies, and cohort studies were included. Review articles, meta-analyses, case studies, guidelines, and animal experiment studies were excluded.

Additionally, studies published in non-English language were excluded.

Data extraction and management

The following data were extracted from each study: first author, year of publication, country, study design, median follow-up, sample size, hernia type (ventral hernia or groin hernia), excised organs, repair procedure (mesh repair or primary repair; organ resection or no resection), and the number of major and minor complications in each group. What is more, according to the Clavien-Dindo complication scoring system [23], the complications of Clavien-Dindo I–II were defined as minor complications including wound infection, scrotal ecchymosis, urinary retention, testicular edema, testicular atrophy, seroma, ileus, postoperative pain, wound dehiscence, mesh reaction, epididymitis, fat necrosis, and superficial surgical site injury. At the same time, the complications of Clavien-Dindo III–IV were defined as major complications containing pneumonia, atelectasis, heart failure, myocardial infarction, anastomotic leak, strangulation, fistula, bladder injury, mesh infection, and deep surgical site infection. Subsequently, when analyzing the efficacy of polypropylene mesh in emergency settings for both incisional and inguinal hernias, we selected similar complications in both types of hernias as outcome measures to reduce heterogeneity. Therefore, specific-disease-related complications such as scrotal ecchymosis, urinary retention, testicular edema, testicular atrophy, epididymitis, and bladder injury were not included in the analysis. Any disagreements were settled through discussion. Institutional review board approval was not required for this kind of paper.

Statistical analysis

Data suitable for meta-analyses were analyzed and figures were made using the Review Manager, Version 5.3 (The Cochrane Collaboration, Copenhagen, Denmark). The meta-analyses were carried out according to the PRISMA guidelines [24]. In our study, the treatment of dichotomous outcomes was expressed as odds ratio (OR), or ratio difference (RD). The cumulative weighted odds ratio of complications between the organ resection group and the no resection group in incarcerated or strangulated hernias with mesh repair was calculated using a binary random-effect model with a 95% confidence interval (CI) [25]. The random-effect model with a 95% CI was also used to evaluate the odds ratio of complications and recurrences between the mesh repair group and the primary repair group in incarcerated or strangulated hernias. In addition, the same model was used to estimate the ratio difference of the similar complications for subgroup analyses on the severity of complications (major vs minor) and the type of hernias (groin vs ventral) between mesh repair and primary repair in incarcerated or strangulated hernias. What is more, the binary fixed-effect model with a 95% CI was chosen to conduct a meta-analysis to estimate a cumulative weighted odds ratio of complications between mesh repair and primary repair in incarcerated or strangulated hernias with organ resection. Statistical heterogeneity was evaluated using I^2, we chose a random-effect model to perform a meta-analysis if the statistical heterogeneity given by the I^2 value was more than 50%. A forest plot was then constructed with a P-value < 0.05 considered statistically significant.

The risk of bias assessment was carried out using the Newcastle–Ottawa Scale, which ranges from 0 to 9 points [26], where a high number of points represents a low risk of bias. The risk of bias assessment was used to assess the overall quality of the evidence of the included studies and investigate whether there is potential heterogeneity. Potential confounders relevant to the included studies were: hernia type, the severity of complications, sex (female/male-ratio), and age. The publication bias assessment was performed by using a funnel plot of comparison of complications between mesh repair and primary repair in incarcerated or strangulated hernias.

Results

Study selection and identification

Figure 1 shows the PRISMA flow diagram of the article selection process. At first, we gained 179 related articles through database searching. After retrieving and assessing these articles, the 9 remaining observational comparing studies [27–35] were included for evaluation and analysis.

Characteristics of included studies

The characteristics of the included studies and detailed information are listed in Table 1, these studies were published between 2010 and 2021. All the patients were diagnosed with incarcerated or strangulated groin or ventral hernias, and these patients underwent mesh repair or primary repair with or without organ resection. 2 studies [27, 35] were prospective trials, and the other 7 studies [28–30, 32–34, 36] were retrospective trials. The organs removed include the small intestine, colon, omentum, ileum and epityphlon. We used major and minor complications in each group as outcome measures. The risk of bias assessment for case–control studies and cohort studies was listed according to the Newcastle–Ottawa Scale (Table 2). The overall median risk of bias was 7 points (range 5–8). The overall quality of 3 studies was considered fair, and the other 6 studies were assessed as good quality.

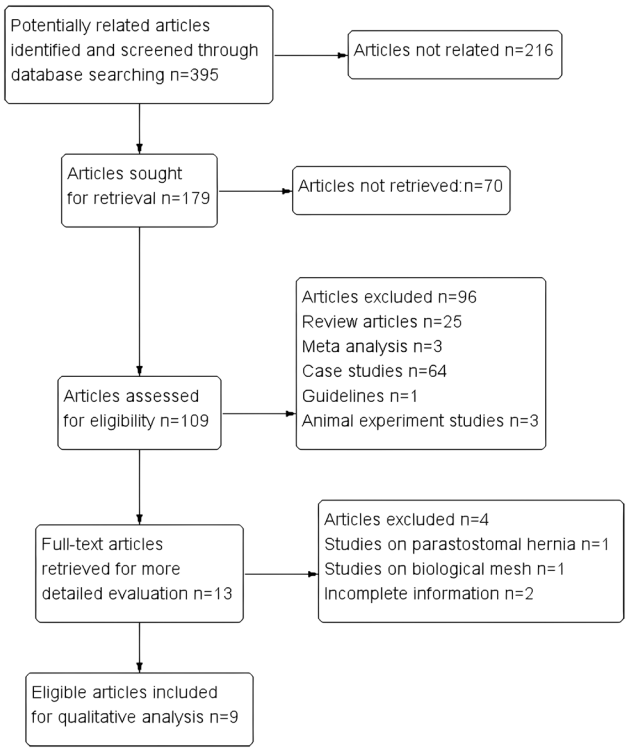

Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of the systematic articles Search

The publication bias for the studies on the outcome of mesh repair in incarcerated or strangulated hernias

The included studies on the outcome of mesh repair in incarcerated or strangulated hernias were symmetrically distributed on both sides of the vertical line, forming an inverted funnel shape, suggesting the absence of significant publication bias. Nevertheless, two studies were not included in the 95% confidence interval, which indicated potential heterogeneity among the studies existed (Fig. 2).

Outcome of mesh repair in incarcerated or strangulated hernias with organ resection

Overall complications of mesh repair with organ resection

These studies [30, 32, 36] including 225 patients reported complications between mesh repair and primary repair of incarcerated or strangulated hernias with organ resection. There was a significant difference between mesh repair and primary repair (OR = 4.93; 95% CI: 2.54, 9.56; P < 0.00001). Complications in the mesh repair group were more than those in the primary repair group. Heterogeneity was low (I^2 = 32%, P = 0.23), and the fixed model was used (Fig. 3).

Subgroup analysis of severity of complications with organ resection

A subgroup analysis of major and minor complications between mesh repair and primary repair in incarcerated or strangulated hernias with organ resection was carried out. There was no significant subgroup difference between the two groups (P = 0.28, I^2 = 12.7%). The complications in the mesh repair group were more than those in the primary repair group in general (RD = 0.17; 95% CI: 0.02, 0.33; P = 0.03). Heterogeneity was very high (I^2 = 71%, P = 0.005), and the random model was used (Fig. 4).

Impact of organ resection in incarcerated or strangulation hernias with mesh repair

Overall complications between organ and non-organ groups

The complications between organ resection and no resection in incarcerated or strangulation hernias with mesh repair were reported in 4 studies [27, 28, 35, 36] involving 491 patients. Although the difference between the two groups was not significant, there was a trend that more complications occurred in patients with the organ resection group (OR = 3.36; 95% CI: 0.86, 13.15; P = 0.08). Heterogeneity was high (I^2 = 60%, P = 0.06), and the random model was used (Fig. 5).

Subgroup analysis on the severity of complications in organ and non-organ resection groups

A subgroup analysis of major and minor complications between organ resection and no resection in incarcerated or strangulated hernias with mesh repair was performed. There was no significant subgroup difference between these groups (P = 0.14, I^2 = 53.3%). Heterogeneity was high (I^2 = 69%, P = 0.002), and the random model was used (Fig. 6).

Overall complications following mesh repair and primary repair

Overall complications

The overall complications between mesh repair and primary repair in incarcerated or strangulated hernias were investigated in 6 studies [29, 30, 32–34, 36] including 862 patients. There was no significant difference between mesh repair and primary repair (OR = 1.61; 95% CI: 0.75, 3.47; P = 0.22). Some of these incarcerated or strangulated hernia repairs were performed with organ resection and others

Table 1 The Characteristics of Included Studies

References	Country	Study design	Median follow up (Months)	Sample size	Type of hernia	Excised organs	Complications (Total)	Complications (Major)[a]	Complications (Minor)[b]
Abd Ellatif et al. [27]	Egypt	Prospective	O&M[c]:48.7 ± 31.3 N&M[d]:42.6 ± 26.6	Total:163 O&M:48 N&M:115	Groin Ventral	Small bowel	Total:17 O&M:5 N&M:12	Total:9 O&M:2 N&M:7	Total:8 O&M:3 N&M:5
Liu et al. [29]	China	Retrospective	34 ± 19	Total:167 O&M:25 N&M:142	Groin	Small bowel Colon	Total:5 O&M:2 N&M:3	Total:0 O&M:0 N&M:0	Total:5 O&M:2 N&M:3
Tomaoglu et al. [29]	Turkey	Retrospective	18.2(1–42)	Total:301 MR[e]: 226 PR[f]::75	Groin Ventral	Omentum Small bowel Others	Total:67 MR: 47 PR::20	Total:5 MR: 2 PR::3	Total:62 MR: 45 PR::17
Ueda et al. [30]	Japan	Retrospective	20(1–120)	Total:27 O&M:10 O&P[g]:17	Groin	Small bowel	Total:11 O&M:5 O&P:6	Total:0 O&M:0 O&P:0	Total:11 O&M:5 O&P:6
Emile et al. [31]	Egypt	Retrospective	MR:24 (6–32) PR:22 (6–30)	Total:122 O&M: 2 O&P:19 N&M:64 N&P[h]:37	Ventral	Bowel	Total:8 O&M: 2 O&P:2 N&M:3 N&P:1	Total:0 O&M: 0 O&P:0 N&M:0 N&P:0	Total:8 O&M:2 O&P:2 N&M:3 N&P:1
Xourafas et al. [32]	Italy	Retrospective	7(1–120)	Total:177 O&M:51 O&P:126	Ventral	Small bowel Colon	Total:39 O&M:23 O&P:16	Total:22 O&M:14 O&P:8	Total:17 O&M:9 O&P:8
Liu et al. [33]	China	Retrospective	24	Total:104 MR:51 PR:53	Groin	Bowel Omentum	Total:26 MR:12 PR:14	Total:0 MR:0 PR:0	Total:26 MR:12 PR:14
Atila et al. [35]	Turkey	Prospective	O&M:47 (25–81) N&M:43.5 (23–109)	Total:95 O&M:14 N&M:81	Groin	Small bowel Epityphlon Omentum Colon Ileum	Total:10 O&M:3 N&M:7	Total:4 O&M:2 N&M:2	Total:6 O&M:1 N&M:5
Derici et al. [34]	Turkey	Retrospective	MR:48.7 ± 31.3 PR:42.6 ± 26.6	Tota:131 MR:29 PR:102	Groin	Bowel	Total:21 MR:7 PR:14	Total:12 MR:4 PR:8	Total:9 MR:3 PR:6

[a]Major complications: the complications of Clavien-Dindo III–IV were defined as major complications containing pneumonia, atelectasis, heart failure, myocardial infarction, anastomotic leak, strangulation, fistula, mesh infection, and deep surgical site infection, [b]Minor complications: the complications of Clavien-Dindo I–II were defined as minor complications including wound infection, seroma, ileus, postoperative pain, wound dehiscence, mesh reaction, fat necrosis, and superficial surgical site injury, [c]O&M: Organ resection & Mesh repair, [d]N&M: No resection & Mesh repair, [e]MR: Mesh repair, [f]PR: Primary repair, [g]O&P: Organ resection & Primary repair, [h]N&P: No resection & Primary repair

Table 2 Risk of bias summary for all included observational case–control and cohort studies

References	Selection	Comparability	Exposure (Outcome)	Total	Quality[a]
Abd Ellatif et al. [27]	4	1	3	8	Good
Liu et al. [29]	4	1	3	8	Good
Tomaoglu et al. [29]	2	0	3	5	Fair
Ueda et al. [30]	3	1	3	7	Good
Emile et al. [31]	3	1	3	7	Good
Xourafas et al. [32]	3	1	3	7	Good
Liu et al. [33]	3	1	2	6	Fair
Atila et al. [35]	2	1	2	5	Fair
Derici et al. [34]	4	1	3	8	Good

[a]the overall quality of bias ranges between good quality (7–9 points), fair quality (4–6 points), and poor quality (0–3 points)

without organ resection, in this case, heterogeneity was high ($I^2 = 74\%$, $P = 0.002$), therefore, the random model was used (Fig. 7).

Recurrences

Five studies [29, 31–34] containing 835 patients reported recurrences between mesh repair and primary repair.

Notably, the recurrence rate of primary repair was significantly higher than that of mesh repair in incarcerated or strangulated hernias with or without organ resection (OR = 0.46; 95% CI: 0.26, 0.82; P = 0.009). Heterogeneity was low (I^2 = 45%, P = 0.12), therefore, the random model was used (Fig. 8).

Subgroup analysis on the type of hernias (ventral vs groin)

The complications between mesh repair and primary repair in incarcerated or strangulated groin hernias were reported in 3 studies [30, 33, 34] involving 262 patients. 2 studies [32, 36] including 299 patients reported the complications between mesh repair and primary repair in the incarcerated or strangulated ventral hernias. Study [29] that did not differentiate patients with groin and ventral hernias and was not included in the meta-analysis.

As shown in Fig. 9, no significant subgroup difference was detected between the groin hernia group and the ventral hernia group comparing mesh repair and primary repair in incarcerated or strangulated hernias (P = 0.21, I^2 = 37.7%). However, subgroup analysis showed that in ventral hernia group, complications in the mesh group tended to be more than those in the primary repair group (OR = 3.33; 95% CI: 0.91, 12.26; P = 0.07). Similarly, some of these incarcerated or strangulated hernia repairs were performed with organ resection. Heterogeneity was high (I^2 = 62%, P = 0.03), and the random model was used. At the same time, the type of hernia could be a source of heterogeneity (Fig. 9).

Subgroup analysis on the severity of complications

There was no significant subgroup difference between the major and minor complication groups comparing mesh repair and primary repair in incarcerated or strangulated hernias (P = 0.86, I^2 = 0%). At the same time, some of these patients underwent organ resection and the other did not.

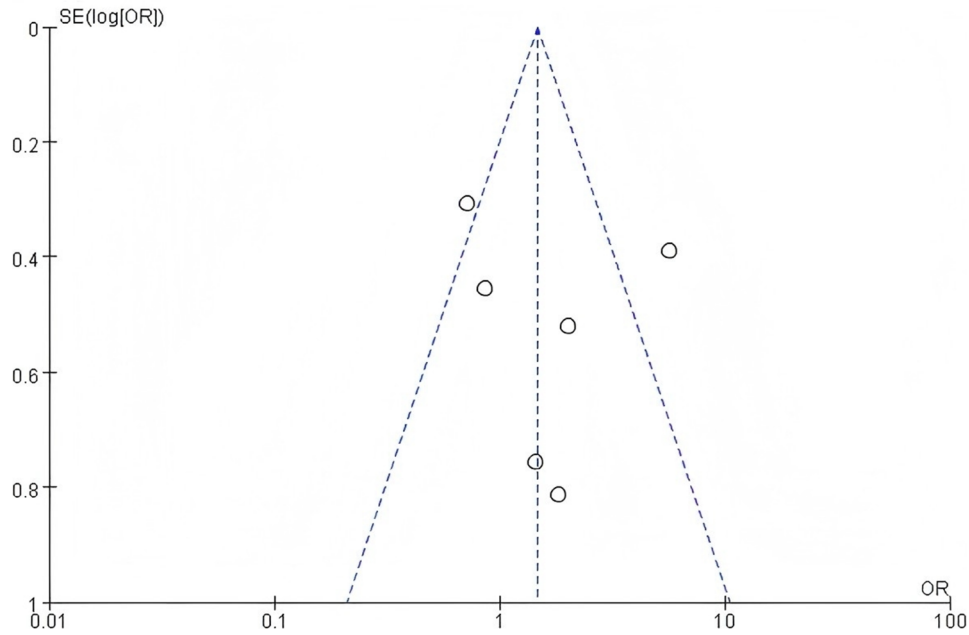

Fig. 2 Funnel plot of studies on overall complications between mesh repair and primary repair in incarcerated or strangulated hernias

Study or Subgroup	Mesh repair Events	Total	Primary repair Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Emile 2017	2	2	2	19	1.5%	35.00 [1.27, 961.31]
Ueda 2012	5	10	6	17	30.1%	1.83 [0.37, 8.98]
Xourafas 2010	23	51	16	126	68.5%	5.65 [2.64, 12.09]
Total (95% CI)		**63**		**162**	**100.0%**	**4.93 [2.54, 9.56]**
Total events	30		24			

Heterogeneity: Chi² = 2.95, df = 2 (P = 0.23); I² = 32%
Test for overall effect: Z = 4.73 (P < 0.00001)

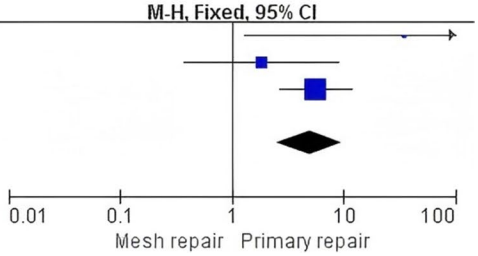

Fig. 3 Forest plot of overall complications between mesh repair and primary repair in incarcerated or strangulated hernias with organ resection

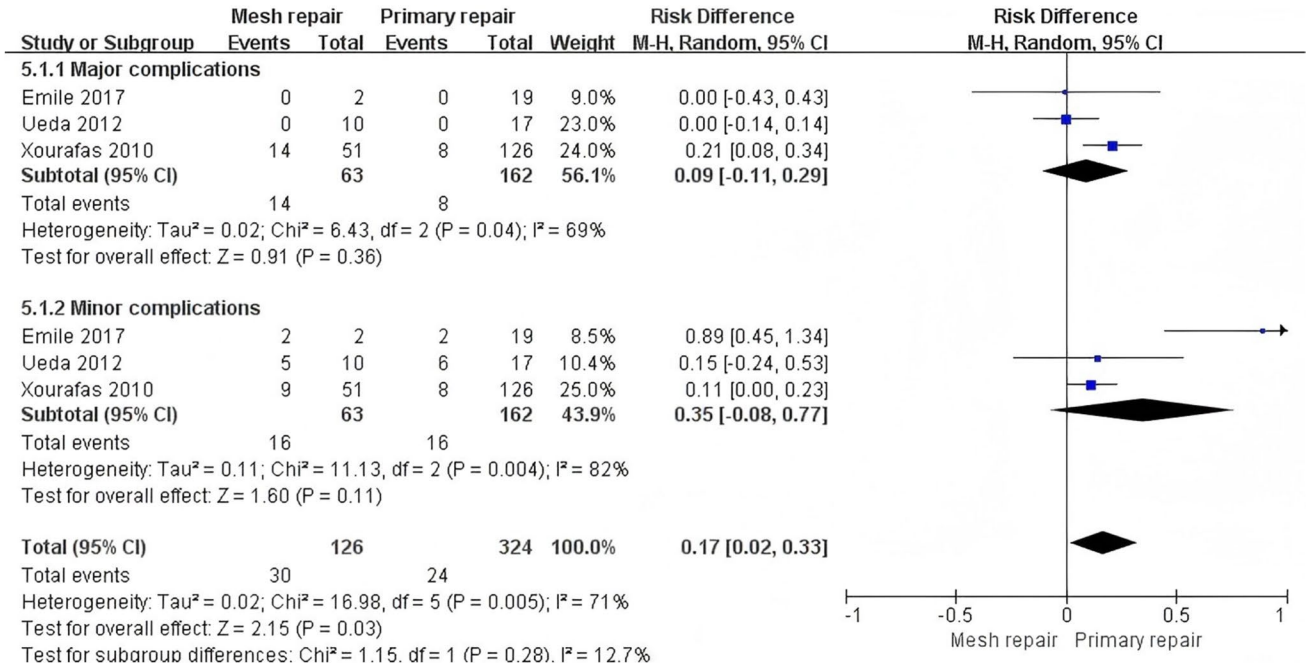

Fig. 4 Forest plot of subgroup analysis of major and minor complications between mesh repair and primary repair in incarcerated or strangulated hernias with organ resection

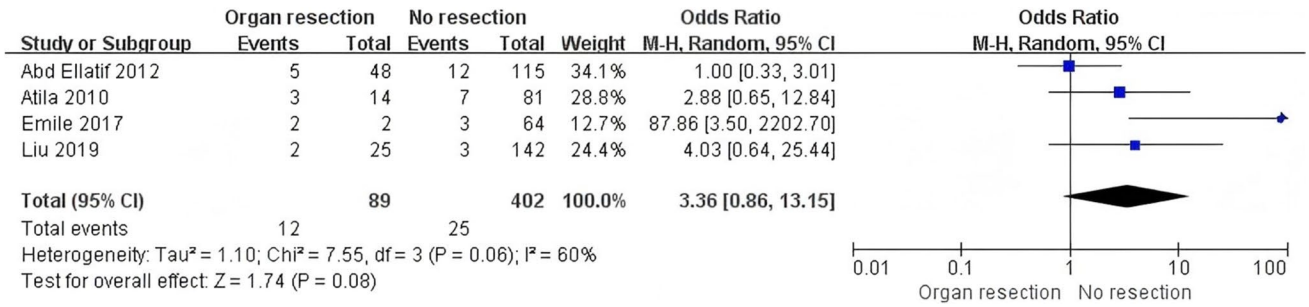

Fig. 5 Forest plot of overall complications between organ resection and no resection in incarcerated or strangulation hernias with mesh repair

Heterogeneity was high ($I^2 = 58\%$, $P = 0.006$), and the random model was used (Fig. 10).

Discussion

Polypropylene mesh, recognized for its durability, inertness, and capacity to induce fibrous proliferation, is extensively employed in hernia repair procedures. Nonetheless, continuous concern was expressed by surgeons regarding the risk of mesh infection during emergency hernia repairs [37, 38]. According to traditional surgical guidelines, the use of synthetic materials is not advised in potentially infected surgical fields, which can increase susceptibility to infection in these conditions [5]. It is widely acknowledged that synthetic meshes may increase the risk of surgical site infections (SSIs) and related complications, at the same time, it is notoriously difficult to manage infected meshes in cases of advanced or chronic infections [39, 40]. In recent years, as studies have investigated the risks associated with mesh repair in strangulated hernias[41, 42], the appropriateness of employing mesh for repairing incarcerated or strangulated hernias has become a considerable debate. In patients with incarcerated or strangulated hernias treated with either mesh repair or primary repair, the current studies have indicated no significant difference in complications between the two approaches [43, 44]. This suggests that strangulated or incarcerated hernias cannot diminish the safety of the mesh, and that mesh can be used in strangulated hernias

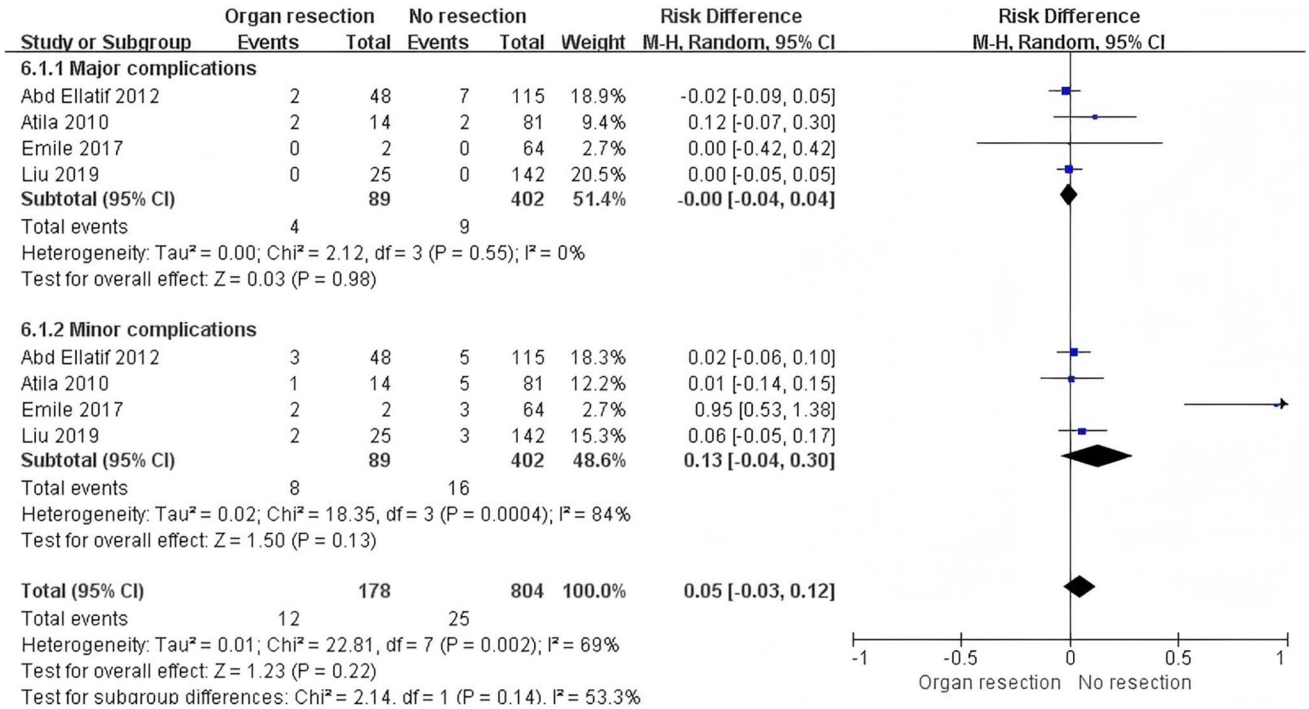

Fig. 6 Forest plot of subgroup analysis of major and minor complications between organ resection and no resection in incarcerated or strangulated hernias with mesh repair

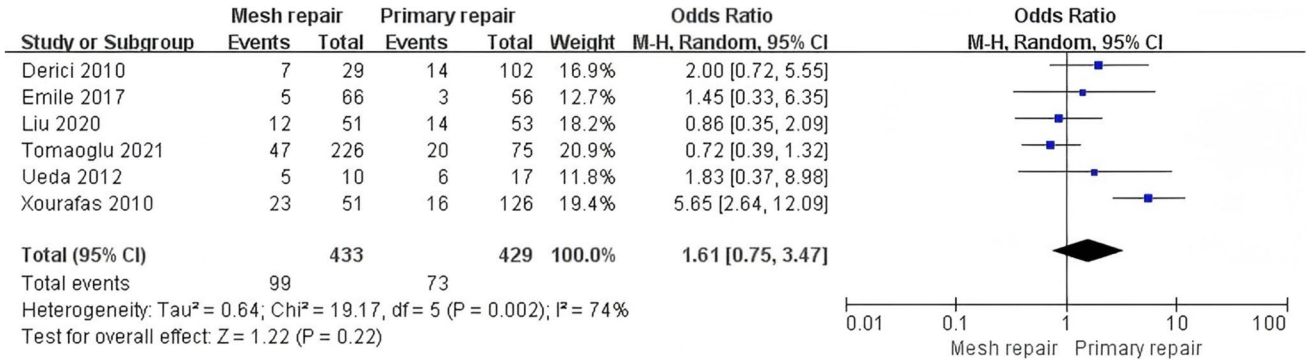

Fig. 7 Forest plot of overall complications between mesh repair and primary repair in incarcerated or strangulated hernias

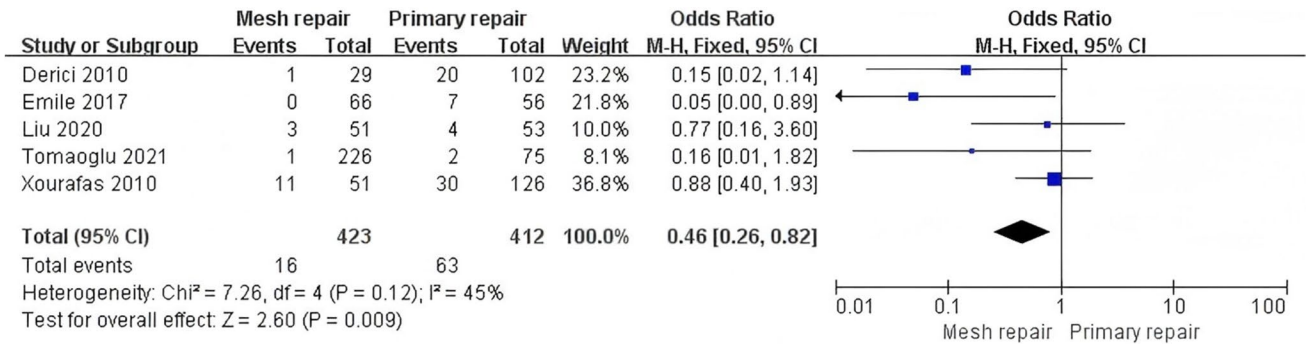

Fig. 8 Forest plot of recurrences between mesh repair and primary repair in incarcerated or strangulated hernias

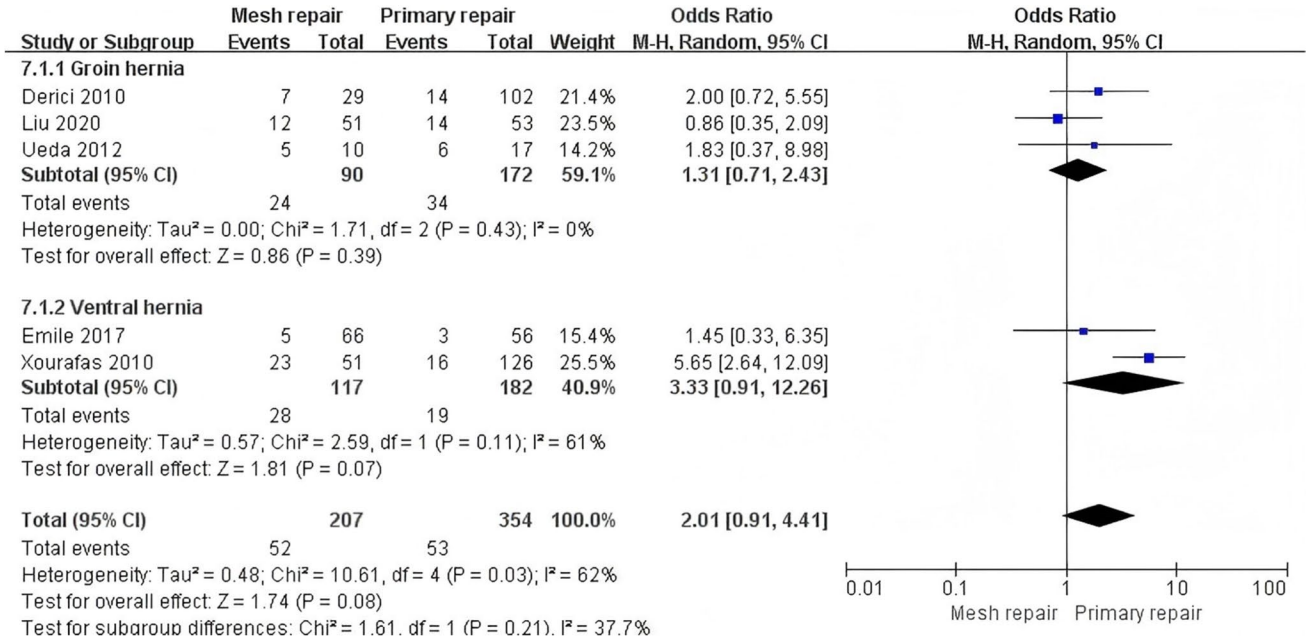

Fig. 9 Forest plot of subgroup analysis of overall complications between mesh repair and primary repair in the incarcerated or strangulated groin hernia and ventral hernia groups

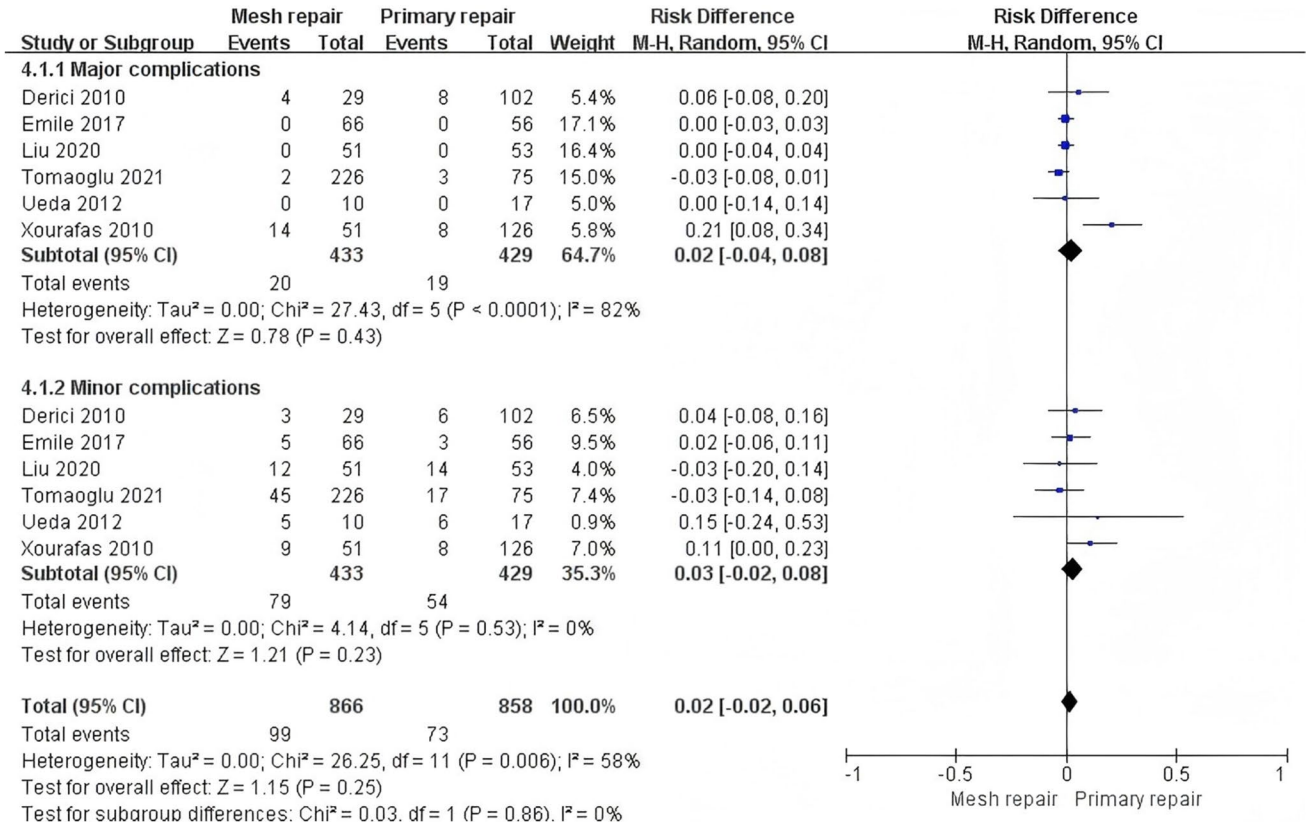

Fig. 10 Forest plot of subgroup analysis of major and minor complications between mesh repair and primary repair in incarcerated or strangulated hernias

with potential risks of infection. However, due to the presence of both resected and non-resected organs in the included strangulated or incarcerated hernias, the impact of organ resection on the safety of mesh in a strangulated hernia remains unclear.

A high risk of wound infection in patients undergoing mesh repair with intestinal resection has been found, which can be mitigated through the timely use of antibiotics or the replacement of wound dressings after surgery [45]. Certain authors asserted that the presence of non-viable intestines cannot be considered a contraindication for mesh repair [8, 9, 14]. Furthermore, many surgeons remain concerned that the increased incidence of surgical site infections in incarcerated and strangulated hernias may be related to mesh implantation [45, 46].

To substantiate these findings, our study divided all strangulated hernia patients who underwent organ resection into the mesh repair group and the primary repair group. The results showed that the incidence of complications in the mesh repair group was significantly higher than that in the primary repair group (OR = 4.93; 95% CI: 2.54, 9.56; P < 0.00001). These findings indicated that when organ resection was performed, the risk of complications increased when mesh was used, potentially due to cavity organ contents overflowing into the surgical field which is classified as a Class III contaminated surgical wound, what is more, potential contamination in the surgical area can impede the use of synthetic mesh. Therefore, synthetic mesh should be used with caution in such environments.

To further investigate the effect of mesh repair on the safety of organ resection in incarcerated or strangulated hernias, in our study, the included patients with incarcerated or strangulated hernias who require mesh repair were divided into two groups: one group underwent organ resection, and the other did not. Our results showed that compared with the no-resection group, A tendency toward increased overall complications in the organ resection group was observed (OR = 3.36; 95% CI: 0.86, 13.15; P = 0.08). This observation implied that organ removal might increase the incidence of complications in Incarcerated or strangulated hernias with mesh repair.

At present, mesh repair is not recommended for ventral hernias under any level of pollution [42]. To further look at the safety of mesh in the treatment of strangulated ventral hernias, in the present study, patients with strangulated or incarcerated hernias were further sub-grouped into ventral hernia group and groin hernia group, and subgroup analyses on these two types of hernias were conducted. Our results showed that there was no significant difference in complications between the mesh group and the primary group in groin hernias, however, there was a tendency for more complications in the mesh repair group compared to the primary repair group in the ventral hernia (OR = 3.33; 95% CI: 0.91, 12.26; P = 0.07). This observation was consistent with previous reports that the use of artificial mesh could significantly increase the risk of infectious and non-infectious complications in patients undergoing ventral hernia repair with intestinal resection. These findings demonstrated that there was a difference in the risk of complications between ventral and groin hernia repair, in case of emergent situation. When dealing with emergent ventral hernia repair, surgeons should bear in mind that, the risk of complications and reoperation is significantly higher [32].

In addition, according to the Clavien-Dindo classification, complications were categorized into major and minor complications, and subgroup analyses were conducted on the severity of complications. The results showed no significant difference between the major and minor complication subgroups comparing mesh repair and primary repair in incarcerated or strangulated hernias with or without organ resection (P = 0.86, I^2 = 0%). Subsequently, it was found that there was no significant difference in the two subgroups comparing organ resection and no resection in incarcerated or strangulated hernias with mesh repair (P = 0.14, I^2 = 53.3%). This indicated that the severity of complications did not significantly influence the assessment of mesh safety in strangulated hernias.

Our study revealed that complications may occur with the placement of mesh in incarcerated or strangulated hernias with or without organ resection. On the one hand, the mesh can be used cautiously in hernia repair surgeries concerning some high-risk factors such as patient age, ASA score, smoking, the duration and emergency setting of the operation[47], which involves different pathophysiologic mechanisms that the risk of synthetic mesh infection can be significantly increased by the presence of adhesions and hematomas, the advanced age of 60–70 years old, a length of surgery of over 90 min, a hernia duration of over 24 months, obesity, and organ functional deterioration[48]. In addition, for patients with strangulated hernia with small or large bowel necrosis or gross enteric spillage (contaminated, CDC wound class III) or peritonitis from small bowel perforation (dirty surgical field, CDC wound class IV), the mesh repair is not recommended [49]. On the other hand, advancements in mesh materials were reported that the safety of repairing incarcerated or strangulated inguinal hernias involving bowel resection could be increased, and the incidence of serious complications could also be reduced such as mesh-associated infection [31, 41, 50]. For example, synthetic mesh alternatives such as biological prostheses can be considered. However, due to high costs, these alternatives have not been readily accessible in all settings. This presents surgeons with a dilemma, where the risk of SSIs is higher when using prosthetic mesh, which has been proved in a study by Xourafas et al. [32], and the recurrence rate is higher when abandoning mesh [51, 52]. To minimize mesh-related

complications, macroporous and lightweight mesh are commonly advised for use in clinical practice, and studies have found that complications, such as pain, seroma, and persistent infections, arose with small pore size and dense mesh [53].

In addition to the incidence of complications, the recurrence rate is also a key postoperative outcome measure when analyzing the efficacy of polypropylene mesh repair in emergency settings. Interestingly, in our study, the recurrence rate of primary repair was significantly higher than that of mesh repair in incarcerated or strangulated hernias (OR = 0.46; 95% CI: 0.26, 0.82; P = 0.009), which implies that mesh repair has the potential to reduce recurrence rates. Due to the lack of stratification for patients with and without organ resection, the accuracy of assessing the recurrence rate following mesh repair in emergencies may be affected. Thus, the impact of mesh repair on recurrence rates of incarcerated or strangulated hernia patients remains a matter of debate, which is worth further exploration.

Limitations of this study: 1. The studies included in this analysis are prospective or retrospective observational comparing studies, which may lead to selection and recall bias. A substantial proportion of the data is retrospective and the entire population may not be represented. The electronic medical records were used for retrospective analysis in the included studies, which may promote potential information bias. 2. In this study, the application of biological mesh was not evaluated in acute incarcerated or strangulated hernias. Employing biological mesh may offer a novel approach to treating complex hernias, particularly in surgical fields at risk of infection. 3. The relatively small number of cases included in the study has a limiting effect on the assessment of the safety of polypropylene mesh in incarcerated or strangulated hernias with organ resection. 4. The impact of surgical procedures on patient prognosis was not considered in this study. Recent studies reported significantly different effects between open repair and endoscopic repair on postoperative complications in patients with inguinal hernias [54]. 5. Furthermore, in addition to organ resection and mesh repair, other risk factors have been identified in incarcerated or strangulated hernias that can affect the incidence of postoperative complications, including underlying diseases [17], the degree of surgical site contamination [19], postoperative care [55], smoking [18] and the diameter of the hernia sac [55]. Additionally, previous studies found that advanced age significantly influenced the recurrence rate, the need for intestinal resection, hospital stay, incidence rate, and mortality [2], suggesting that these factors not considered in this study may impact the evaluation of polypropylene mesh safety. 6. Organ resection in this study was not further sub-grouped into intestine and non-intestine resection, and the effect of intestine resection on polypropylene mesh safety cannot be accurately assessed. 7. On the one hand, the number of studies comparing the efficacy of polypropylene mesh repair in contaminated settings was limited, on the other hand, currently, patients with both ventral hernia and inguinal hernia were analyzed in most clinical trials, rather than analysis of these two types of hernia separately, we inevitably included both ventral hernia and inguinal hernia patients in our analysis. The significant differences in pathological characteristics between these two types of hernias may lead to substantial differences in complications and high heterogeneity. Subsequently, we selected similar complications in the two types of hernia as outcome measures when evaluating the safety of polypropylene mesh repair in cases involving organ resection to further reduce heterogeneity, effectively concluding that a higher rate of complications occurs when using mesh in this criterion.

Conclusion

In cases of incarcerated or strangulated hernias requiring organ resection, the use of polypropylene mesh has been correlated with a higher incidence of complications compared to primary repair. Additionally, a trend was observed toward greater complication rates when ventral hernia repair was performed. Therefore, polypropylene mesh should be used cautiously in strangulated hernias with organ resection or in the repair of the ventral hernia.

Author contributions All authors were involved in the conception, data collection, and analysis of the study. The first draft of the manuscript was written by Yue Ding, and Junsheng Li revised the manuscript several times and checked the quality of the manuscript. All authors read and approved the final manuscript.

Funding No funding was available.

Data Availability The data that support the findings of this study are openly available.

Declarations

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval This article did not require ethical approval of any kind.

Human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent This article does not include patients, and therefore informed consent was not applicable.

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