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REVIEW

Staged versus concurrent ventral hernia repair with metabolic bariatric surgery: a systematic review and meta-analysis of comparative studies

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Abstract

Introduction This study compares the outcomes of concurrent metabolic bariatric surgery (MBS) and ventral hernia repair (VHR) vs. staged VHR approach after MBS.

Method We systematically searched four main databases with relevant keywords. Two independent authors screened and included studies that compared these two approaches. The I^2 statistic was utilized to evaluate heterogeneity among the studies; if exceeded 50%, a random effects analysis was conducted, while fixed effects analysis was employed for those without severe heterogeneity.

Results 7 studies with 9244 and 11,961 patients in concurrent and staged groups were included, respectively. Our results showed that the rate of mesh infection was significantly higher in concurrent VHR (3.6% vs. 1.9%, OR: 2.18, $p<0.001$), and mortality was insignificantly lower in staged VHR (0.3% vs. 0.1%, OR: 1.70, $p=0.09$). Although surgical site infection, seroma, bowel obstruction, hernia recurrence, and reoperation were higher in the staged group, comparisons were statistically insignificant (all $p>0.05$). Furthermore, hematoma, venous thromboembolic events, and wound dehiscence had nearly the same rates.

Conclusion Both approaches are viable options, depending on individual patient circumstances (age, BMI, hernia size, hernia-related symptoms, sac with or without intestinal loops) and surgical preferences (type of MBS, with or without mesh, type of mesh) highlighting the importance of individualized surgical planning for optimization of outcomes and minimizing risks in this specific patient population.

Registration The protocol of this study was submitted to PROSPERO and received the registration code CRD42023444310.

Keywords Bariatric surgery · Hernia repair · Obesity · Ventral hernia repair · Ventral hernia

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Introduction

Ventral hernia (VH) is a common condition observed in patients with obesity, particularly those who are candidates for metabolic bariatric surgery (MBS) [1, 2]. VH poses significant challenges in this population, as the excess intra-abdominal pressure associated with obesity predisposes individuals to the progression of hernia and also development and recurrence of hernias after surgery [3]. MBS, which is increasingly recognized as an effective long-term solution for weight reduction, offers a potential therapeutic pathway for reducing the risk of VH recurrence by addressing the underlying obesity [4, 5]. However, the timing of ventral hernia repair (VHR) in the context of MBS remains a controversial issue. The management of VH in MBS candidates is fraught with complexity. Concurrent VHR during MBS procedures may result in a higher incidence of wound complications, mesh infection, and hernia recurrence [5–7]. In contrast, delaying hernia repair until after significant weight loss has been achieved might reduce these risks, as weight reduction leads to decreased intra-abdominal pressure and enhanced wound healing capacity [7, 8]. However, postponing hernia repair also presents risks, as untreated hernias can enlarge or become incarcerated, leading to emergent surgical intervention for obstruction [9].

Several studies have explored the outcomes of concurrent VHR and MBS compared to staged approaches, yet consensus remains obscure [10]. Advocates of concurrent repair claim that a single surgical intervention reduces the overall morbidity associated with multiple surgeries, limits hospital stay, and decreases the risk of future complications related to hernia progression [4, 11]. On the other hand, those in favor of a staged approach highlight the potential benefits of weight loss prior to VHR, such as lower recurrence rates and fewer postoperative complications [5, 7, 8].

Given the rising prevalence of obesity worldwide and the increasing number of patients undergoing MBS procedures, determining the optimal timing for VHR in this population is of critical importance. In this systematic review, we aim to compare the outcomes of concurrent MBS and VHR versus staged VHR (MBS first).

Methods and material

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used for conducting and reporting the findings of this study. The protocol of this study was submitted to PROSPERO and received the registration code CRD42023444310.

Search and screening

PubMed, Scopus, Embase, and Web of Science were systematically searched with relevant keywords until May 11, 2024. The inclusion criteria were studies reporting the outcomes of concurrent MBS and VHR versus staged VHR (MBS first). Any type of article other than original contributions (case report, editorial, review, or conference presentations), experimental studies on animals, and non-English reports were excluded. Furthermore, single-arm studies without a control group were not included. After excluding duplicate studies, two independent authors conducted the screening process, and another author resolved the conflicts.

Concurrent MBS and VHR was defined as performing VHR and MBS for a patient with VH and severe obesity at the same time in one operation. Staged VHR refers to VHR performed after MBS.

Data extraction

Data from the included studies (first author's name, year of publication, country, design of the study, sample size of each group, age, gender, BMI before MBS, MBS technique, available data regarding the type, location, size, and width of the hernia, applying mesh for VHR, VHR's surgical technique (open, laparoscopic, or robotic), hospital length of stay, follow-up after surgery, any postoperative complications including surgical site infection (SSI), seroma, hematoma, wound dehiscence, bowel obstruction, recurrence, reoperation, and any time mortality, venous thromboembolism (VTE), and mesh infection) extracted by the same two authors. The difference observed in any step was resolved by another investigator independent of the other three.

The Newcastle Ottawa Scale (NOS) was used to assess the quality of studies. After evaluating each study, "Good quality" and "Fair quality" cases were included in the final meta-analysis, and "Poor quality" cases were not included in the study.

Statistical analysis

The data were presented as mean ± standard deviation. In cases where the median and interquartile range or range for a variable were available, the conversion to mean and standard deviation was performed using the formulas proposed by Hozo et al., Luo et al., and Wan et al. [12–14]. For the purpose of statistical analysis, Stata/SE version 17 (StataCorp LLC) was employed. Stata reports the results of pooled analyses of categorical variables as log odds ratios. Odd ratio = e^ (log odds ratio) was used for converting log odd ratio to odd ratio. The I^2 statistic was utilized to evaluate heterogeneity among the studies. An I^2 value exceeding

50% indicated severe heterogeneity. For variables demonstrating severe heterogeneity, a random effects analysis was conducted, while fixed effects analysis was employed for those without severe heterogeneity. A P-value of less than 0.05 was considered statistically significant for inference.

Results

The PRISMA flow chart of included articles is shown in Fig. 1. A total of 1629 articles were obtained from a systematic search of databases by keywords. After deduplication and title/abstract screening, 20 full-text articles were assessed for eligibility, and seven articles met the inclusion criteria of comparing both concurrent and staged VHR. No articles were added by manual search. Finally, seven articles with 9244 and 11,961 patients in concurrent and staged groups were included in the current study. All the included studies were observational. The types of MBS were Roux-en-Y gastric bypass, sleeve gastrectomy, and gastric banding. Four studies mentioned that VHR procedures were laparoscopic, two studies used both open and laparoscopic approaches, and one did not report the details of their surgical steps. Table 1 presents the important and most reported characteristics of the included studies.

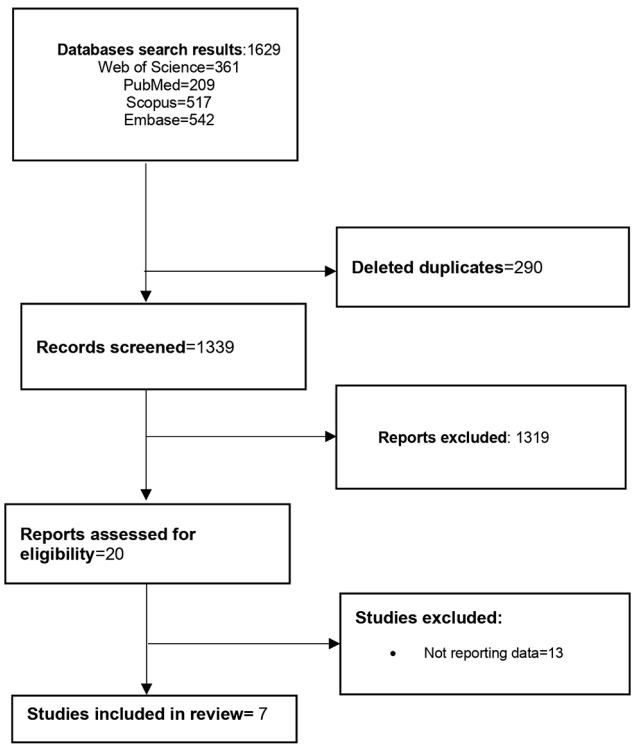

Fig. 1 PRISMA flowchart of the included studies

Post-VHR complications

Mesh infection

A fixed-effects pooled analysis of 2 studies with 577 concurrent and 3525 staged VHR showed that the rate of mesh infection was significantly higher in the concurrent group (3.6% vs. 1.9%, OR: 2.18 [1.32–3.60], $p<0.001$) (Fig. 2).

SSI

Seven studies evaluated and reported SSI, which was not significantly different between concurrent and staged groups (4.5% vs. 6.4%, respectively, OR: 1.12 [0.55–2.25], $p=0.76$) (Fig. 3.A).

Seroma

Three studies reported seroma after VHR; with two studies noting only one case in the staged group. The rate of seroma formation was not significantly different between groups (2% for the concurrent and 6.5% for the staged VHR, OR: 0.29 [0.07–1.23], $p=0.09$) (Fig. 3.B).

Hematoma

Only two studies found hematoma in their population without statistically significant difference between them (both 2.4%, OR: 1.01 [0.12–8.17], $p=0.99$) (Fig. 3.C).

VTE

Four studies observed this complication in their patients and our pooled analysis did not show a significant difference between concurrent versus staged groups after MBS (0.47% vs. 0.41%, OR: 1.21 [0.78–1.89], $p=0.40$) (Fig. 3.D).

Bowel obstruction

Despite being highly frequent in the staged group (9.5% vs. 0.9%), the rate of obstruction among the four studies was not significantly different (OR: 0.19 [0.01–2.34], $p=0.19$) (Fig. 4.A).

Recurrence

The pooled rate of hernia recurrence among five studies was higher in the staged group (24.2% vs. 9.4%) despite being statistically insignificant (OR: 0.91 [0.22–3.90], $p=0.91$) (Fig. 4.B).

Table 1 Characteristics of included studies

Author	Country	Type of study	Type of MBS	Follow-up Time	Sample Size (case vs. control)	Type of hernia	Mesh or Suture	Hernia size	Mean Preoperative BMI	MIS or open
Eid, 2004 [9]	United States	Retrospective	All RYGB	26 months	71 vs. 14	61 primary ventral 24 incisional ventral hernia	Both	7.74 (2–16) (concurrent) vs. 17.7 (9–50) (concurrent Small intestine submucosa repair) vs. 14.5 (4–25) (staged) cm^2	49.3 (concurrent) vs. 52.1 (concurrent Small intestine submucosa repair) vs. 56 (staged)	MIS
Khanna, 2024 [11]	Australia	Retrospective	SG ($n=30$), RYGB ($n=65$), and GB ($n=16$) vs. SG ($n=11$), RYGB ($n=7$), and GB ($n=3$)	Median 1.97 (0.11–13.6) years vs. 3.43 (0.9–14.1) years	111 vs. 23	primary: 57/111 (51.4%). Incisional: 54/111 (48.6%). vs. primary: 8/21 (38.1%). Incisional: 13/21 (61.9%).	Mesh 102/111 (91.9%) vs. 20/21 (95.2%)	NR	Median: 43.1 (27.7–69.7) vs. 46.0 (35.6–58.0)	MIS: 106/110 (96.4%) vs. 15/21 (71.4%)
Datta, 2008 [8]	United States	Retrospective	RYGB	14(range 4–30) months	18 vs. 8	NR	Both	NR	NR	MIS
Khorgami, 2017 [7]	United States	Retrospective	RYGB ($n=544$) and SG ($n=444$) for each group	30 days	988 vs. 988	NR	NR	NR	48.0±9.0 vs. 48.3±8.1	In concurrent group: open 322 (32.6%) and MIS 666 (67.4%)
Moolla, 2019 [5]	United States	Retrospective	RYGB ($n=1930$) and SG ($n=2718$) vs. RYGB ($n=1923$) and SG ($n=2725$)	30 days	4648 vs. 4648	NR	NR	NR	46.2±8.5 vs. 46.0±8.4	MIS
Vitiello, 2021 [4]	Italy	Retrospective	All SG	19.8±5.6 months	20 vs. 20	Umbilical Hernia	Mesh	Small/Medium	42.7±4.9 vs. 31±4.3	Both
Moszkowicz, 2021 [6]	France	Retrospective	SG and RYGB	Median 3.2 years (1.4–6.0), and 2.9 years (1.3–5.0) years	3388 vs. 6260	NR	Mesh ($n=470$ (13.9%)) and Suture ($n=2918$ (86.1%)) vs. Mesh ($n=3504$ (56%)) and suture (2756 (44.0%))	NR	NR	NR

Versus indicates a comparison between concurrent and staged approaches, SG: sleeve gastrectomy, RYGB: Roux-en-Y gastric bypass, GB: gastric banding, NR: not reported, MIS: minimally invasive surgery

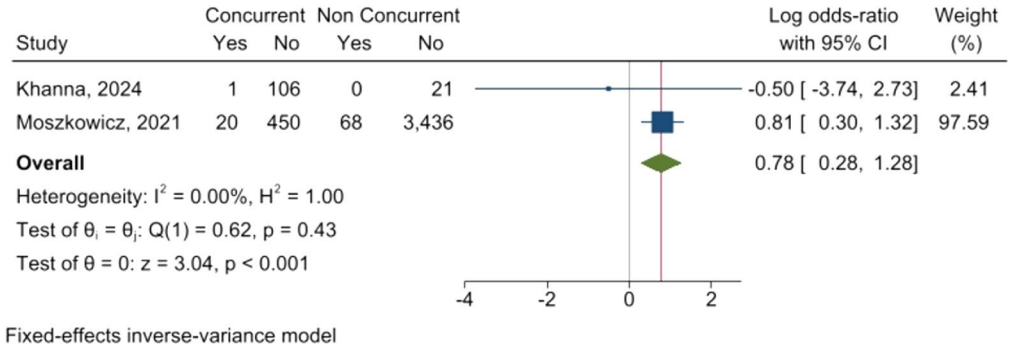

Fig. 2 Pooled analysis of Mesh infection rate between concurrent and staged groups

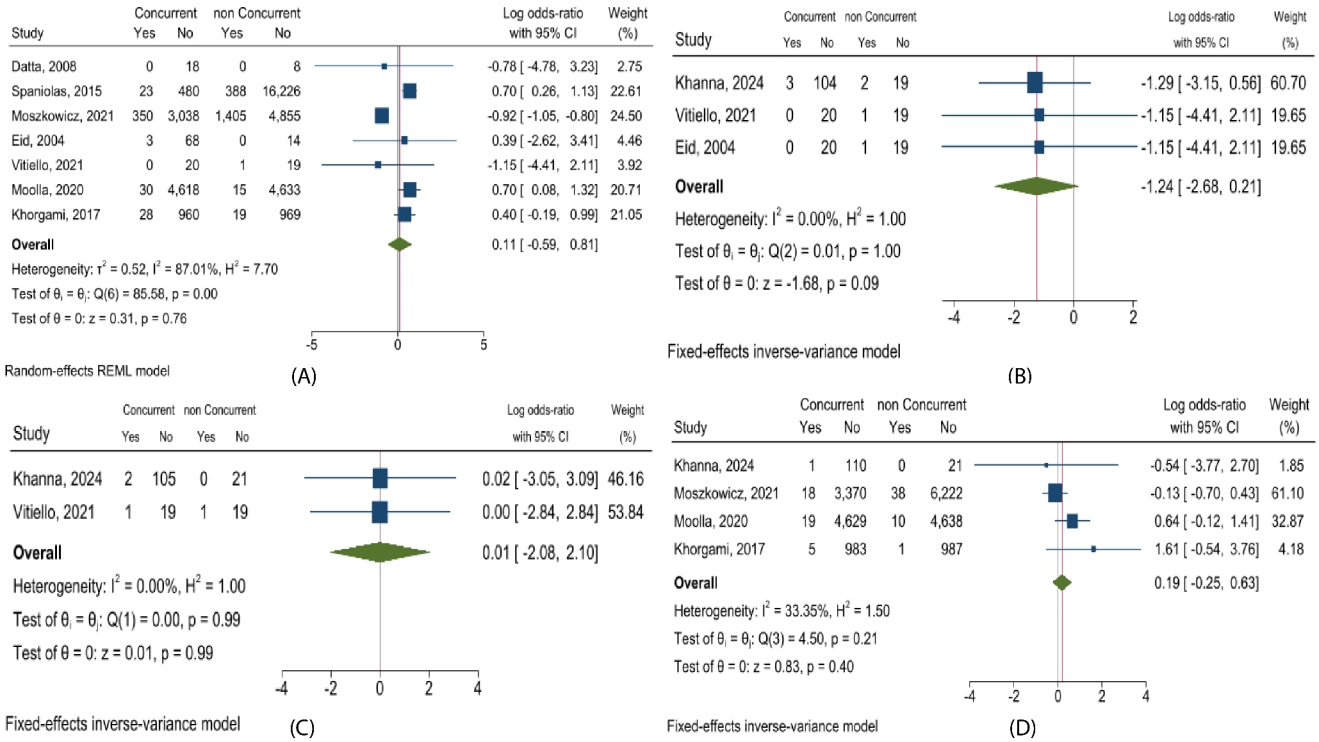

Fig. 3 Pooled analysis of surgical site infections (**A**), Seroma (**B**), Hematoma (**C**), and venous thromboembolic events (**D**) rates between concurrent and staged groups

Reoperation

The rate of reoperation, which was stated by eight studies, was not significantly different between concurrent and staged VHR groups (3.2% and 5%, respectively, OR: 0.90 [0.29–2.83], $p=0.86$) (Fig. 4.C).

Mortality

Six studies reported the rate of mortality after VHR, which was not significantly different between groups (0.3% for concurrent and 0.13% for staged VHR, OR: 1.70 [0.92–3.16], $p=0.09$) (Fig. 4.D).

Wound dehiscence

Wound dehiscence was reported in three studies and was not significantly different between groups (both 0.1%, OR: 0.73 [0.24–2.20], $p=0.58$) (Fig. 5.A).

Length of stay

Hospital length of stay reported in five studies as not significantly different between groups (mean difference= -1.12 [-2.91-0.67], $p=0.22$) (Fig. 5.B).

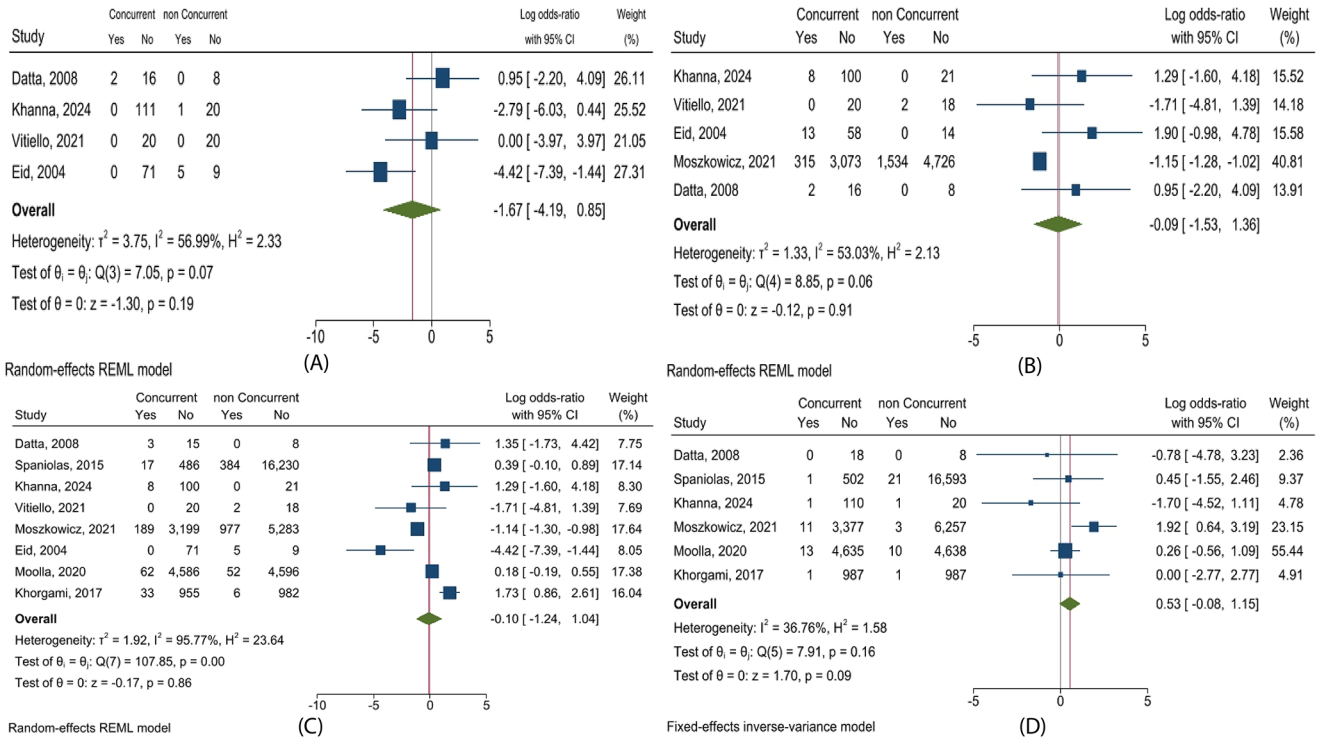

Fig. 4 Pooled analysis of bowel obstruction (**A**), recurrence (**B**), reoperation (**C**), and mortality (**D**) rate between concurrent and staged groups

Quality assessment

Table 2 shows the results of the quality assessment of included studies with two-armed comparative groups. Four and three studies had low and moderate risk of bias, respectively. No studies had a high risk of bias.

Discussion

Performing concurrent MBS and VHR has been debated due to the potential for increased complications compared to staged VHR. This approach is particularly beneficial in patients with small defects that do not require mesh or in cases where the hernia sac contains intestinal loops, as the risk of bowel obstruction is significant. Indeed, it increases operative time and complexity, which can heighten intraoperative and postoperative risks. However, with the rising number of MBS procedures, VHR during these surgeries is becoming more common. Despite this, the literature lacks consensus on the optimal timing for VHR in patients undergoing MBS because most studies did not separate different BMI categories, selection criteria for mesh, type of mesh, detailed VHR approach, and type of MBS in each group, all of which may alter the flow of decision [15]. This systematic review and meta-analysis on comparative studies, included seven articles with 9,244 and 11,961 patients in the concurrent and staged groups, respectively, highlights several key findings. A significantly higher risk of mesh infection was observed in the concurrent group. However, rates of SSI, seroma, wound dehiscence, hematoma, hernia recurrence, reoperation, and mortality were not significantly different between the two approaches. This suggests that while simultaneous VHR presents an elevated infection risk, other outcomes are comparable between the groups. Our findings are in line with a recent systematic review and meta-analysis of this kind with the same concerns but with pooling results from all studies (both single-arm and comparative) reporting VHR with concomitant MBS or as staged groups [10]. The choice between approaches hinges on several factors:

Type of surgery

One critical consideration is the risk of contamination and deep SSI in clean-contaminated fields, particularly with synthetic mesh [5, 15]. Studies, including those by Cozacov et al., suggest that the type of surgery plays a critical role; SG, for example, creates a cleaner field compared to RYGB due to the lack of gastric lumen opening [16]. However, Khanna et al. did not show any significant difference in the rate of mesh infection between concurrent and staged groups in subgroups of SG, RYGB, and gastric banding [11]. Few studies reported their outcomes based on the MBS types, and more research is needed for this aspect on whether

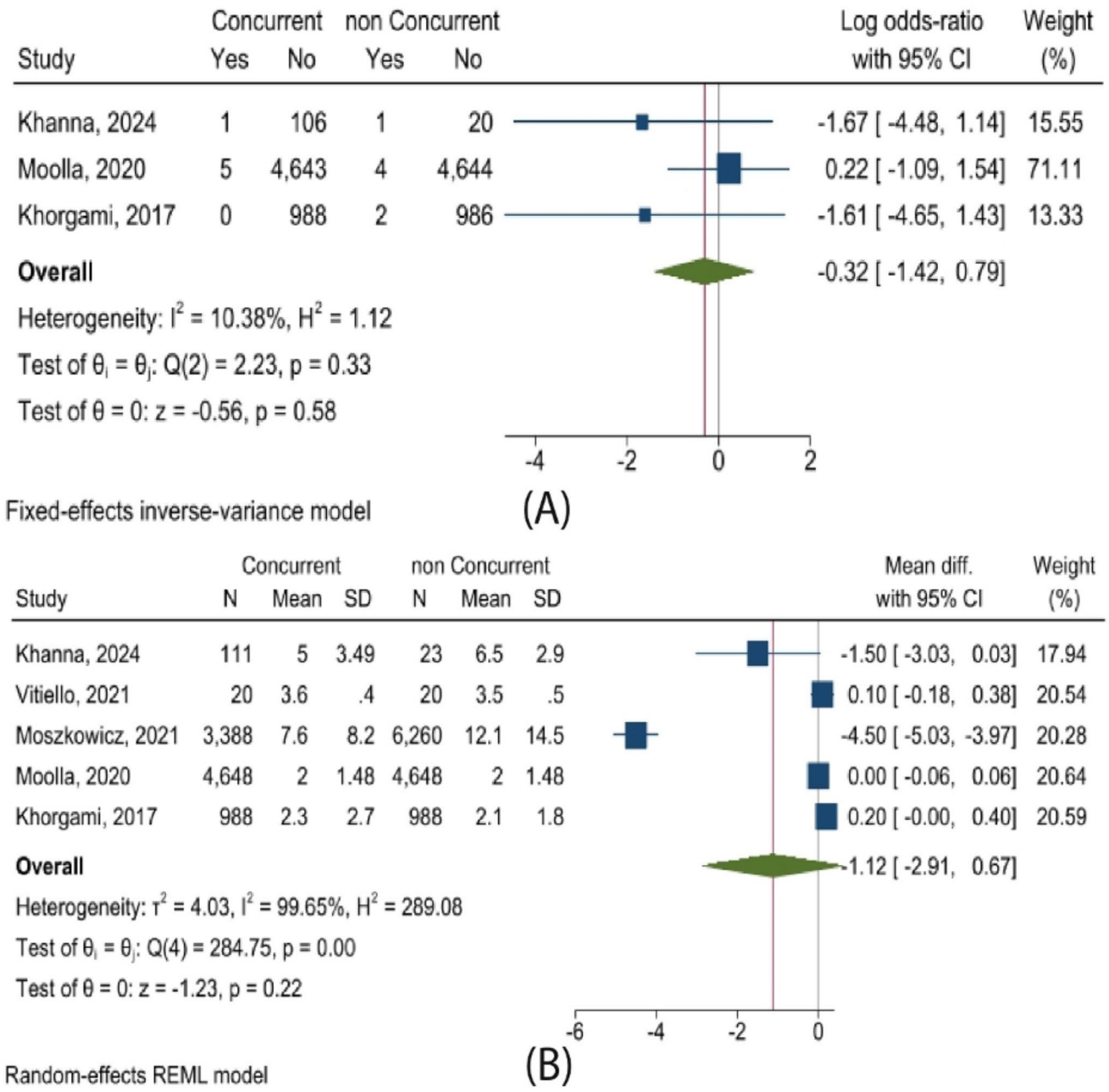

Fig. 5 Pooled analysis of rate of wound dehiscence (**A**) and length of stay (days) (**B**), between concurrent and staged groups

applying mesh does anything to do with the type of surgery and any type of infection rates.

Hernia size

As an influential decision-making factor, large hernias often require extensive dissection and repair techniques unsuitable for the laparoscopic methods typically employed during MBS. Furthermore, large hernias will recur if being repaired without mesh, mostly in patients with higher BMIs [17]. Small defects (<2–4 cm) discovered incidentally during surgery can often be repaired to prevent future complications such as bowel strangulation; failure to address even small symptomatic defects risks emergent surgeries with poor outcomes. The 2018 ASMBS/AHS guidelines recommend a staged approach for patients with large hernias or those unsuitable for minimally invasive repair [2, 18]. Olmi et al. recommended that small hernias (<4 cm) should be managed by either concurrent mesh repair or primary repair with suture as bridge treatment followed by a deferred permanent repair with mesh after losing weight

Table 2 The results of quality assessment using Newcastle-Ottawa quality assessment scales for observational studies

Items		Eid, 2004 [9]	Khanna, 2024 [11]	Datta, 2008 [8]	Khorgami, 2017 [7]	Moolla, 2019 [5]	Vitiello, 2021 [4]	Moszkowicz, 2021 [6]
Selection	Representativeness of the exposed cohort	B (star)	B (star)	B (star)	B (star)	B (star)	B (star)	B (star)
	Selection of the non-exposed cohort	A (star)	A (star)	A (star)	A (star)	A (star)	A (star)	A (star)
	Ascertainment of exposure	A (star)	A (star)	A (star)	A (star)	A (star)	A (star)	A (star)
	Demonstration that outcome of interest was not present at start of study	A (star)	A (star)	A (star)	A (star)	A (star)	A (star)	A (star)
Comparability	Comparability of cohorts on the basis of the design or analysis	No star	A (star)	No star	A (star) B (star)	A (star) B (star)	A (star)	No star
Exposure	Assessment of outcome	B (star)	B (star)	B (star)	B (star)	B (star)	B (star)	B (star)
	Was follow-up long enough for outcomes to occur	A (star)	A (star)	A (star)	B	B	A (star)	A (star)
	Adequacy of follow up of cohorts	B (star)	B (star)	B (star)	C	C	B (star)	B (star)
Overall risk of bias		Moderate	Low	Moderate	Low	Low	Low	Moderate

[19]. For large hernias, staged treatment is more favorable after losing significant weight [19].

Patient characteristics

High BMI, age, and obesity-related medical problems increase the complexity of surgery and the risk of recurrence or complications, favoring a staged approach. High BMI has been associated with the occurrence of hernia and wound complication rates exceeding 50% [17, 20]. Additionally, obesity-related diabetes increases the likelihood of wound infections [21]. For such patients, staged VHR after MBS may allow for weight loss and improved glycemic control, reducing surgical risks [2]. Conversely, deferring VHR increases the risk of hernia obstruction [9]. We should notice that hernia will recur if being repaired when the patient has a BMI above a threshold (BMI > 40 kg/m^2). Previous investigations did not evaluate the odds of hernia recurrence based on a specific BMI at the operation. Finally, patients with hernia-related symptoms or a history of bowel incarceration may benefit from immediate repair, especially with the use of permanent sutures or dual-layer mesh techniques to prevent life-threatening complications.

Despite these considerations, our findings show no significant difference in rates of seroma, SSI, wound dehiscence, hematoma, recurrence, reoperation, or VTE between concurrent and staged groups. This underscores that both approaches are viable, depending on individual patient circumstances (age, BMI, obesity-associated medical diseases, hernia size, hernia-related symptoms, hernia sac with or without intestinal loops) and surgical preferences (type of MBS, with or without mesh, type of mesh). Clinicians must counsel patients on the risks and benefits of both approaches. Immunocompromised patients, such as those with poorly controlled diabetes, may benefit from staged VHR due to lower infection risks. However, the logistical and surgical risks of two separate procedures must also be weighed. When avoiding a second surgery is a priority, concurrent VHR remains a practical and acceptable option. Ultimately, an individualized approach that accounts for hernia characteristics, patient comorbidities, and surgical expertise is essential for optimizing outcomes.

Several limitations should be acknowledged. Although all of the included studies were comparative between groups, none of them were randomized trials, necessitating the need for detailed, specifically designed studies for this subject. Besides studies reporting from large national databases, multiple surgeons were involved in all studies, which may further influence the decision process and final outcome. The absence of a detailed surgical approach, variations in characteristics of ventral hernias across different studies, and the lack of specific information about ventral hernias in large database studies (type of MBS, hernia size, and frequency of different BMI categories in each group) are the limitations of our study. Furthermore, the included studies varied regarding patient populations (BMI, type of MBS, hernia size), surgical techniques (laparoscopic, robotic or open VHR, bio-degradable or synthetic mesh), and follow-up durations (hernia may take time to recur); these factors may contribute to significant heterogeneity in some of the pooled analyses.

Conclusion

While concurrent MBS and VHR are associated with a higher risk of mesh infection, the rates of other complications, including SSI, seroma, wound dehiscence, hematoma, VTE, recurrence, reoperation, bowel obstruction, and mortality, are comparable to the staged hernia repair. These findings highlight the importance of individualized surgical planning to optimize outcomes and minimize risks in this patient population.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10029-025-03320-z.

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Data availability The full data of this systematic review is presented in Table 1.

Declarations

Disclosure statement None.

Conflict of interest Nothing to declare.

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