



Mesh versus suture for elective primary umbilical hernia open repair: a systematic review and meta-analysis

Ana Caroline Dias Rasador¹ · Carlos André Balthazar da Silveira¹ · Diego Laurentino Lima² · Raquel Nogueira² · Flavio Malcher³ · Prashanth Sreeramoju¹ · Leandro T. Cavazzola⁴

Received: 16 May 2024 / Accepted: 1 July 2024

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Abstract

Purpose Recent guidelines indicate the use of mesh in UHR for defects > 1 cm, as it reduces recurrence, with 10% recurrence rate compared to up to 54.5% with primary closure. However, Nguyen et al. shows that primary closure is still widely performed in UHR, especially for small defects (1–2 cm), for which there is no published data to determine the optimal approach. In addition, previous meta-analysis by Madsen et al. comparing mesh repair with primary closure in UHR didn't exclude emergency conditions and recurrent hernias; also, didn't report subgroup analysis on hernia defect size. Thus, we aimed to perform a systematic review and meta-analysis comparing the mesh repairs vs. primary closure of the defect in an open elective primary UHR.

Methods We searched for studies comparing mesh with suture in open UHR in PubMed, Scopus, Cochrane, Scielo, and Lilacs from inception until October 2023. Studies with patients ≤ 18 years old, with recurrent or emergency conditions were excluded. Outcomes were recurrence, seroma, hematoma, wound infection, and hospital length of stay. Subgroup analysis was performed for: (1) RCTs only, and (2) hernia defects smaller than 2 cm. We used RevMan 5.4. for statistical analysis. Heterogeneity was assessed with I^2 statistics, and random effect was used if $I^2 > 25\%$.

Results 2895 studies were screened and 56 were reviewed. 12 studies, including 4 RCTs, 1 prospective cohort, and 7 retrospective cohorts were included, comprising 2926 patients in total (47.6% in mesh group and 52.4% in the suture group). Mesh repair showed lower rates of recurrence in the overall analysis (RR 0.50; 95% CI 0.31 to 0.79; $P=0.003$; $I^2=24\%$) and for hernia defects smaller than 2 cm (RR 0.56; 95% CI 0.34 to 0.93; $P=0.03$; $I^2=0\%$). Suture repair showed lower rates of seroma (RR 1.88; 95% CI 1.07 to 3.32; $P=0.03$; $I^2=0\%$) and wound infection (RR 1.65; 95%CI 1.12 to 2.43; $P=0.01$; $I^2=15\%$) in the overall analysis, with no differences after performing subgroup analysis of RCTs. No differences were seen regarding hematoma and hospital length of stay.

Conclusion The use of mesh during UHR is associated with significantly lower incidence of recurrence in a long-term follow-up compared to the suture repair, reinforcing the previous indications of the guidelines. Additionally, despite the overall analysis showing higher risk of seroma and wound infection for the mesh repair, no differences were seen after subgroup analysis of RCTs.

Study registration A review protocol for this systematic review and meta-analysis was registered at PROSPERO (CRD42024476854).

Keywords Mesh · Suture · Umbilical hernia repair · Paraumbilical hernia

✉ Diego Laurentino Lima
dilaurentino@gmail.com

¹ Bahiana School of Medicine and Public Health, Dom João VI Avenue, 275, Brotas, BA 40290-000, Brazil

² Department of Surgery, Montefiore Medical Center, 1825 Eastchester Rd, Bronx, NY 10461, USA

³ Division of General Surgery, NYU Langone, New York, NY, USA

⁴ Department of Surgery, Federal University of Rio Grande do Sul, Porto Alegre, Brazil

Introduction

Umbilical hernia repair (UHR) is one of the most common general surgery procedures, with a 6–14% incidence per year in adults [1–3]. The surgical approach for umbilical hernia repair has recently been the subject of debate. Several studies report UHR with mesh is associated with lower recurrence rate [4–8], with up to 10% compared to up to 54.5% with primary closure of the defect [2, 9]. These results have oriented the recent guidelines on the topic, which indicate the use of mesh for umbilical hernia defects greater than 1 cm [10].

Despite the recent indication of mesh repair for umbilical hernias > 1 cm [10], suture repair is still commonly performed during UHR, especially for smaller hernias (1–2 cm) [11, 12]. According to the Herniated Registry [12, 13], 75% of patients with small umbilical hernias (< 2 cm) are still offered suture repair. On the other hand, the use of mesh may be associated with higher rates of wound infection, seroma, and hematoma when compared to primary closure of the defect [2, 14, 15].

A recent meta-analysis [16] published in 2020 compared the use of mesh with primary closure for UHR, however, it included heterogeneous retrospective studies and didn't exclude emergency conditions and recurrent umbilical hernias. In addition, that study didn't report subgroup analysis on hernia size, which maintains the gap in the literature regarding the best approach for smaller umbilical hernias. Therefore, we aimed to perform a systematic review and meta-analysis comparing the open mesh repair with the primary closure of the defect for an elective primary umbilical hernia.

Methods

This meta-analysis was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement [17]. A description of the study protocol was registered to the International Prospective Register of Systematic Reviews (PROSPERO) under protocol number CRD42024476854.

Eligibility criteria

The studies included in this meta-analysis met all the following eligibility criteria: (1) open mesh repair as an intervention group; (2) primary suture repair as a control group; (3) performed umbilical or periumbilical hernia repair; (4) included primary and elective umbilical hernias.

We excluded studies that have (1) recurrent hernias; (2) ventral hernias other than umbilical or paraumbilical

hernias; (3) no postoperative outcomes; (4) no full paper available; (5) overlapping populations.

Search strategy and data extraction

The MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, Scielo, and LILACS databases were searched without date or language restrictions on studies that met the eligibility criteria published from inception up to October 2023. The search strategy included the following terms: “umbilical hernia”, “paraumbilical hernia”, “primary ventral hernia”, “epigastric hernia”, “mesh”, “prolene hernia system”, “prosthesis”, “suture”, “anatomical repair”, “primary closure”, “closure”, and was conducted independently by two authors (C. S. and A. R.).

The references from all included studies, previous systematic reviews and meta-analyses were also searched manually for any additional studies. Eventual conflicts were resolved by consensus among the authors. Data extraction was performed by the same two authors independently and data was then compared. A last review was conducted by a third author (D. L.).

Endpoints

The primary outcomes included postoperative complications: (1) seroma, (2) hematoma, (3) wound infection, (4) recurrence.

The secondary outcome was hospital length of stay (LOS). Surgical site occurrences (SSO), including seroma, hematoma, and surgical site infection were defined similarly by all included studies, according to the Centers for Disease Control and Prevention (CDC) [18] and the Ventral Hernia Working Group definitions [19]. Seroma was defined as “an abnormal accumulation of serous fluid in a dead space containing plasma and lymphatic fluid”. Hematoma was defined as “a collection of blood outside the blood vessels”. Finally, surgical site infection was defined as “an infection involving the skin, subcutaneous tissue, and/or deep soft tissues within 30 days of the surgical procedure”.

Subgroup analyses were performed including only RCTs, studies with sublay mesh position, and with only hernia defect sizes smaller than 2 cm.

Quality assessment

The risk of bias was assessed using the Revised Cochrane Risk of Bias Tool [20, 21], assessing randomization, concealment, blinding, intention to treat, baseline comparisons, concomitant interventions, and completeness of follow-up. Non-randomized studies biases were assessed using the ROBINS-I [21]. Two authors (A.R. and C.S.) independently

assessed the risk of bias in each study and discrepancies were resolved by a third author (D.L.) after discussing the reasons for divergence.

To assess the certainty of evidence, we used the Grading Recommendations, Assessment, Development, and Evaluation (GRADE) tool [16]. Using the GRADEpro Guideline Development Tool, two independent authors (A.R. and C.S.) rated the strength of recommendations and other authors resolved disagreements (R.N. and D.L.).

Statistical analysis

Study and patients baseline characteristics are presented descriptively. Normality was checked by plotting a frequency distribution. For continuous outcomes, we used mean differences (MD) as an effect measurement, with a 95% CI. We used the Mantel-Haenszel test to compute risk ratios (RR) for dichotomous outcomes, with 95% confidence intervals (CIs) as a measure of effect size. P-values of less than 0.05 were considered statistically significant. Cochran Q test, I^2 statistics, and visual inspection of the Forest plots were used to assess heterogeneity. We classified I^2 values of < 25%, 25–75%, and > 75% as representing low, moderate, and high heterogeneity, respectively. If the visual inspection was suggestive of heterogeneity in an effect size, the p value < 0.10 or I^2 statistics > 25%, heterogeneity was considered significant, and the DerSimonian and Laird random-effect model was used.

Furthermore, we performed a funnel plot as needed to investigate heterogeneity between study-specific estimates. For outcomes presenting statistically significant results, with high heterogeneity, we performed a sensitivity analysis with leave-one-out test. The statistical analysis was performed using Review Manager 5.4 (Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark).

Results

Study selection and characteristics

The primary search yielded 2895 results. After the removal of duplicates, 2194 studies were screened by title and abstracts, of which 2138 were excluded by not meeting the inclusion criteria, and 56 were selected for full review. After the final review, a total of 12 studies were included comprising 2926 patients, of whom 1401 (47.6%) were in the mesh group and 1525 (52.4%) in the suture group (Fig. 1).

All the 12 included studies were published between 2005 and 2023 on umbilical or periumbilical hernia repairs, and none of the studies include recurrent hernias or emergency procedures. There were four RCTs, one prospective cohort

analysis, and seven retrospective cohort studies. The follow-up ranged from 12 to 54 months among the included patients.

The full study and patient characteristics are presented in Table 1. A total of 2926 patients were included in the study, 894 (30.3%) were females, the mean age ranged between 49 and 57 years old, and the mean BMI ranged between 28 and 36 kg/m².

Quality assessment

The overall risk of bias in randomized studies ranged from low risk in three studies to moderate risk of bias in one study. Bias in those studies was raised mainly from the deviations from the intended intervention and missing outcome data. For the non-randomized studies, the risk of bias was low for four studies and moderate for the other four studies. Reasons for bias arousal were due to confounding factors, selections of participants, and missing outcome data. The full risk of bias assessment is available in Fig. 2.

Pooled analysis

Primary outcomes – postoperative complications

Seroma rates were assessed in 7 studies. Our study found significant differences between mesh repair and primary suture groups, with higher rates of seroma with mesh repair (5.9% vs. 3.0%), favoring the suture group (RR 1.88; 95% CI 1.07 to 3.32; $P=0.03$; $I^2=0\%$; Fig. 3). No differences were seen regarding hematoma between both groups (RR 0.65; 95% CI 0.27 to 1.57; $P=0.34$; $I^2=0\%$).

Overall, 9 studies assessed wound infection incidences. The mesh group was associated with higher rates of wound infection (4.6% vs. 3.0%), favoring the suture repair (RR 1.65; 95%CI 1.12 to 2.43; $P=0.01$; $I^2=15\%$; Fig. 4).

All analyzed studies reported recurrence rates between both mesh and suture groups. All studies but one assessed the incidence of recurrence within ≥ 12 months of the surgery, with a mean follow-up ranging between 12 and 70 months. Only one study presented a follow-up shorter than one year, with a mean of 6 months. Six studies assessed the presence of recurrence through physical examination, and four of them also used ultrasound and/or computerized tomography (CT) in case of doubt in the diagnosis. Three studies assessed recurrence via telephone or e-mail questionnaires, inviting patients to perform physical examination in case of positive response from the patient. Finally, two studies assessed recurrence through telephone call only, without additional diagnostic strategies, and one study didn't provide data on how recurrence was assessed. The mesh group was associated with lower rates of recurrence



PRISMA Flow Diagram

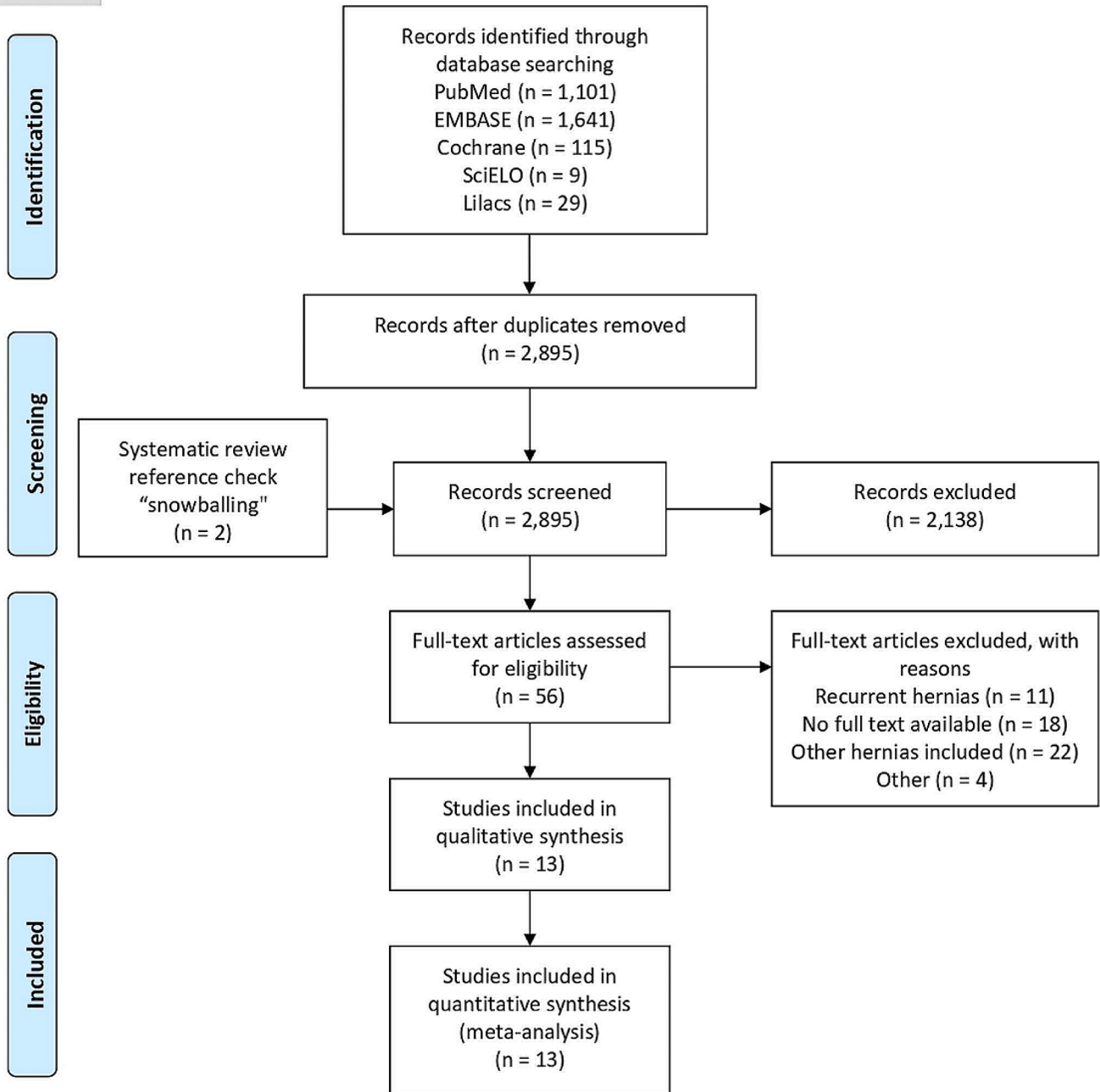


Fig. 1 PRISMA flow diagram of study screening and selection

Table 1 Baseline characteristics of the studies included

Study	Study design	No. (%) of patients (Mesh/Suture)	Mesh position	Mesh material/type	Suture technique	Hernia size † (cm) (Mesh/Suture)	Female sex (%) (Mesh/Suture)	Age (y) (Mesh/Suture)	BMI † (kg/m ²) (Mesh/Suture)	Smoking history (No.)
Venclauskas 2017 ¹²	OR	52 (26%) / 146 (74%)	Onlay and sublay	NA	Keel's technique	4.64 (4.36) / 2.69 (1.21)	53.8% / 66.4%	54.9 (12.7) / 54.5 (16.8)	36 (6.9) / 30.4 (7)	21.2% / 19.9%
Sanjay 2005 ²⁹	OR	39 (39%) / 61 (61%)	Sublay	Polypropylene	Mayo's repair or interrupted suture	< 5	23% / 36%	54.3 (11.8) / 53.2 (15.3)	34.9 (8.1) / 31.6 (4.5)	NA
Sadiq 2013 ³⁰	RCT	30 (50%) / 30 (50%)	NA	NA	Mayo's repair or interrupted suture	> 3	90% / 93%	NA	NA	NA
Polat 2005 ²⁴	RCT	32 (64%) / 18 (36%)	Onlay, inlay, and sublay	PHS and flat polypropylene	Mayo's repair	< 4	72% / 78%	49 (12) / 53.7 (11)	NA	NA
Mitura 2021 ³¹	OR	104 (65%) / 57 (35%)	Sublay	Composite polypropylene	Short-stitch technique	1.5 (0.1) / 1.2 (0.3)	36% / 37%	49.3 (10.3) / 47.8 (13.9)	30.2 (4) / 28.1 (4.5)	29.8% / 12.3%
Kaufmann 2018 ¹³	RCT	146 (49%) / 138 (51%)	Sublay	Polypropylene	Continuous or interrupted suture	1-4	16% / 18%	54.8 (3.6) / 51 (3.7)	28 (0.9) / 28 (1.4)	11% / 18%
Frey 2023 ²⁷	OP	590 (50%) / 590 (50%)	Sublay	NA	NA	< 1 cm	35% / 36%	55.2 (14.4) / 54.2 (14.7)	26.9 (5.4) / 26.4 (5.1)	20.9% / 16.5%
Farrow 2008 ³²	OR	65 (43%) / 87 (57%)	NA	Polypropylene	NA	NA	NA	NA	NA	NA
Dalenbäck 2012 ²³	OR	21 (16%) / 111 (84%)	Onlay, inlay, and sublay	Polypropylene, PHS, and plug	Mayo's repair or interrupted suture	> 1	NA	NA	NA	NA
Berger 2014 ²⁸	OR	90 (50%) / 90 (50%)	Sublay	Polypropylene	Interrupted suture	4.7 (0.3) / 2 (0.2)	NA	NA	32.5 (0.4) / 30.5 (0.3)	NA
Asolati 2006 ³³	OR	132 (54%) / 97 (46%)	Onlay and inlay	NA	NA	1-3	NA	NA	NA	NA
Arroyo 2001 ²⁵	RCT	100 (50%) / 100 (50%)	NA	Polypropylene	Interrupted suture	1-3	58% / 60%	NA	NA	NA

†Mean; RCT: Randomized Controlled Trial; OR: Observational Retrospective; OP: Observational Prospective; BMI: Body mass index; NA: not available

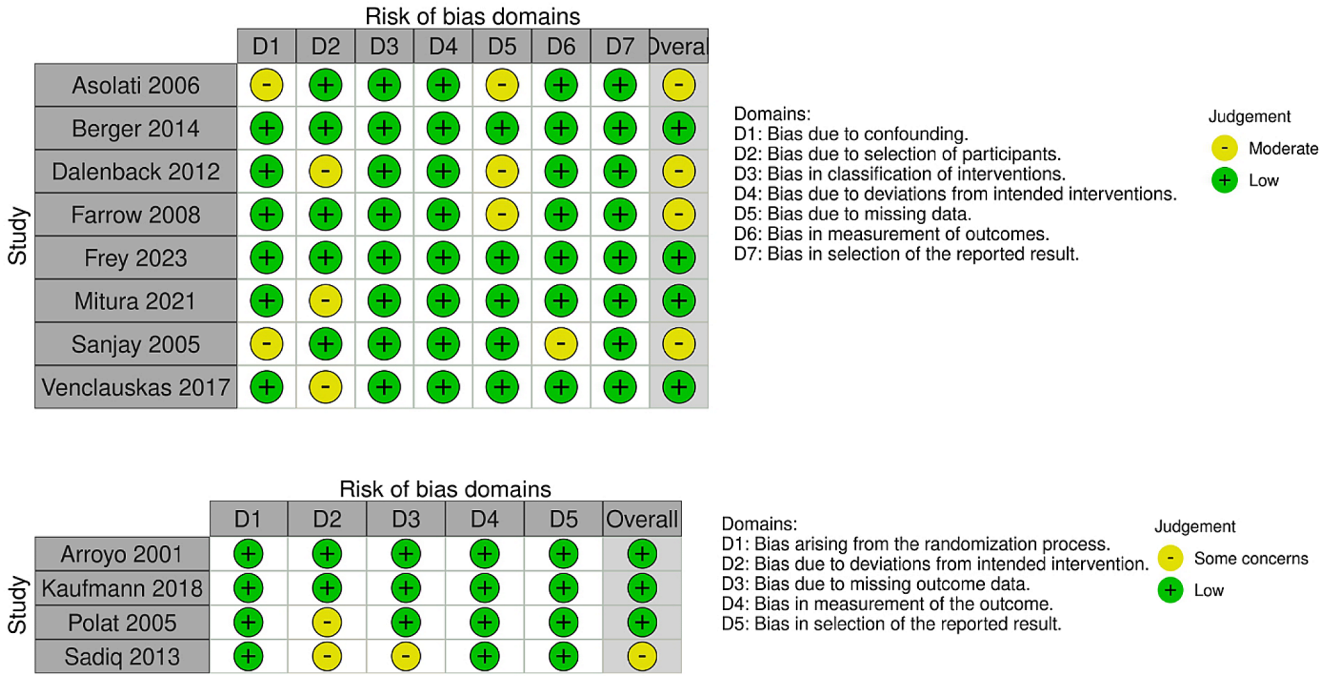


Fig. 2 Risk of bias of included studies

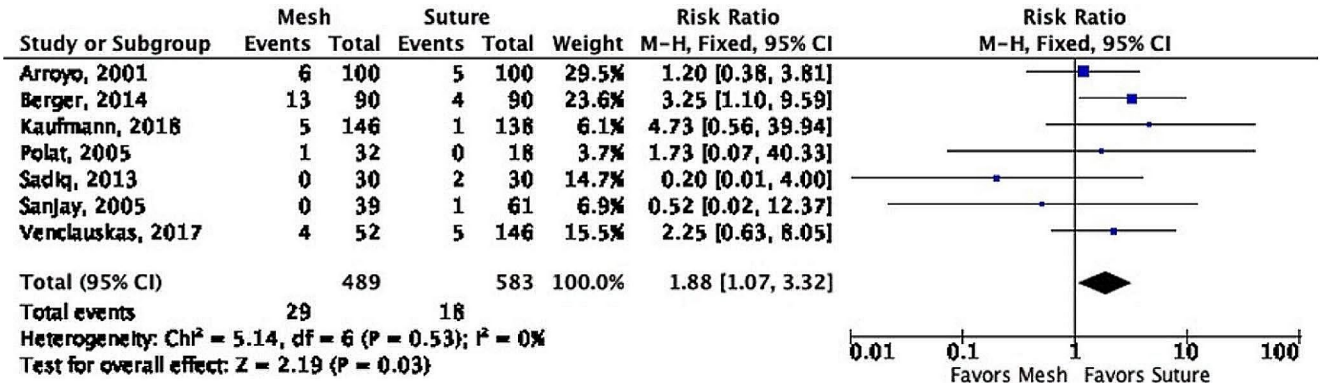


Fig. 3 Meta-analysis of seroma rates favored the suture group

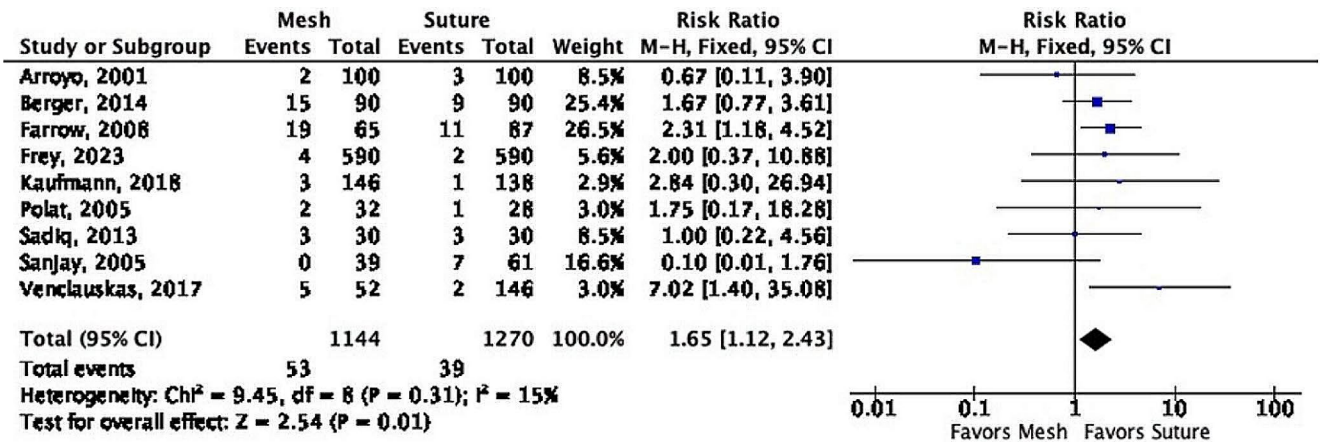


Fig. 4 Meta-analysis of wound infection rates favored the suture group

(3.4% vs. 7.3%), favoring the mesh repair (RR 0.50; 95% CI 0.31 to 0.79; $P=0.003$; $I^2=24\%$; Fig. 5A).

Secondary outcomes

In the meta-analysis of hospital length of stay, no differences were seen between mesh and suture repairs (MD 0.96; 95%CI -0.46 to 2.34; $P=0.18$; $I^2=89\%$).

Subgroup analyses

Subgroup analysis of RCTs

The subgroup analysis of only RCTs showed similar results as the overall analysis for recurrence rates also favoring the mesh repair (RR 0.30; 95% CI 0.15 to 0.61; $P=0.0008$; $I^2=17\%$; Fig. 5B). However, regarding seroma (RR 1.13; 95% CI 0.45 to 2.8; $P=0.8$; $I^2=0\%$), hematoma (RR 0.64; 95% CI 0.23 to 1.76; $P=0.39$; $I^2=0\%$), and wound infection rates (RR 1.13; 95% CI 0.45 to 2.8; $P=0.8$; $I^2=0\%$) no differences were seen between both groups in the subgroup analysis.

Subgroup analysis of mesh position

A subgroup analysis comprising studies with sublay positioning of the mesh was performed. The mesh position definitions followed the classification of the European Hernia Society (EHS) guidelines [22], in which the studies included defined “sublay” as the mesh being positioned in the retro-muscular or preperitoneal space. The subgroup analysis showed similar results as the overall analysis for recurrence (RR 0.51; 95% CI 0.33 to 0.79; $P=0.003$; $I^2=0\%$), favoring the sublay mesh group. Regarding seroma, our subgroup also showed similar results as the overall analysis, (RR 2.9; 95% CI 1.18 to 7.51; $P=0.02$; $I^2=0\%$), favoring the suture group compared to the sublay mesh. Contrarily, the sublay mesh group showed no differences from suture regarding wound infection (RR 1.54; 95% CI 0.80 to 2.97; $P=0.19$; $I^2=23\%$), contrasting with the results reported in the overall analysis. Subgroup analysis for hematoma was not possible.

Subgroup analysis of hernial defects < 2 cm

We also performed a subgroup analysis for recurrence rates in hernia defects ≤ 2 cm, which showed similar results as the recurrence overall analysis. The mesh repair was also

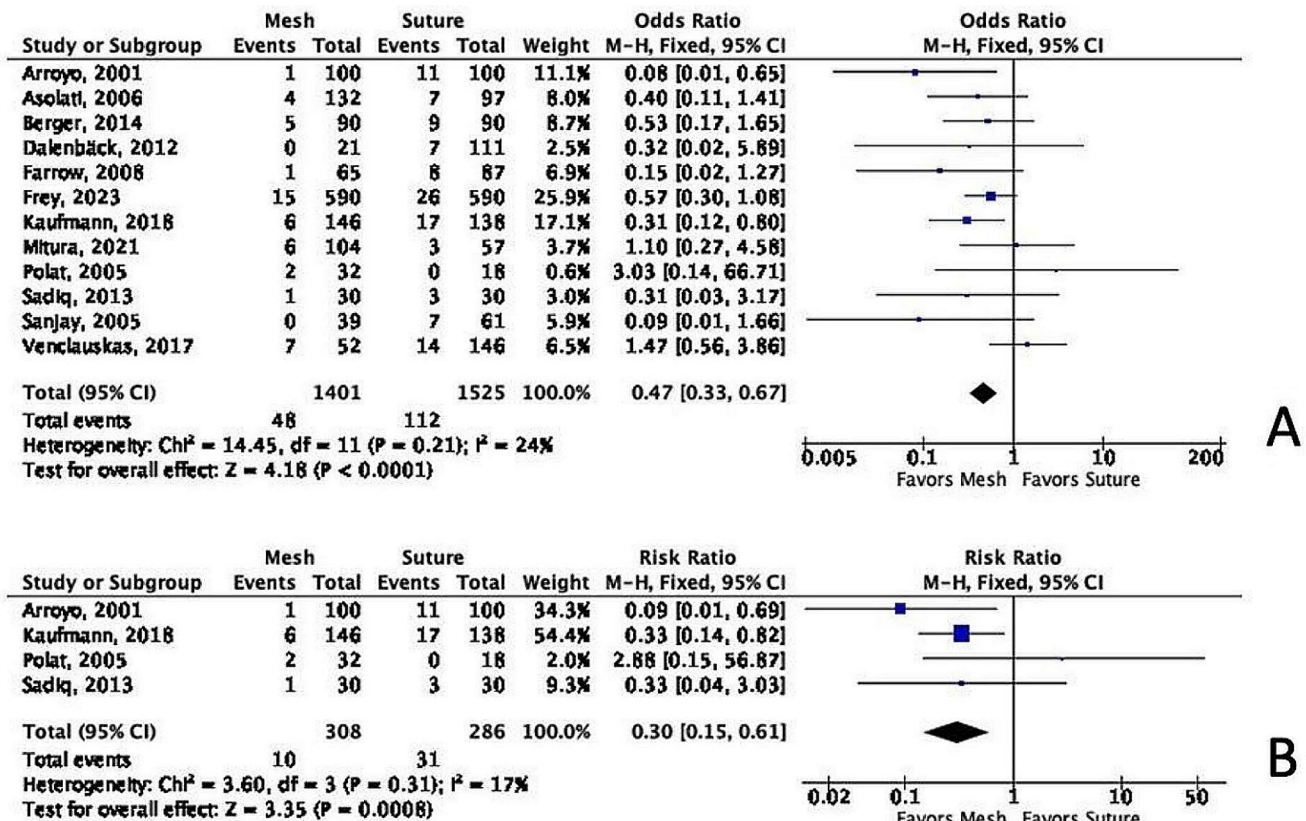


Fig. 5 (A) Meta-analysis of recurrence rates favored the mesh group. (B) Subgroup analysis of recurrence rates with RCTs only favored the mesh group

associated with a lower incidence of recurrence when compared to the primary closure of the defect (RR 0.56; 95% CI 0.34 to 0.93; $P=0.03$; $I^2=0\%$; Fig. 6). Subgroup analysis for defect size was not possible for the other outcomes included in this meta-analysis.

Discussion

In this systematic review and meta-analysis of 12 studies and 2926 patients, the use of mesh was associated with a lower incidence of recurrence and higher incidence of seroma and wound infection when compared to primary closure of the defect during UHR. After performing a subgroup analysis of RCTs only, on the other hand, no differences were seen between mesh and suture for seroma and wound infections. Finally, no differences were seen regarding hematoma and hospital length of stay between suture and mesh groups.

Surgery is indicated in symptomatic patients with umbilical hernia, and it can be performed either by only suture repair or with the use of mesh. Recent guidelines [10] indicate the use of mesh for UH with defects greater than 1 cm, due to its association with low recurrence rates up to 10% compared to up to 54.5% with primary closure of the defect [2, 9]. However, the use of mesh may be associated with a higher incidence of early postoperative complications, such as seroma and wound infection [14, 15].

Despite the recent indications for mesh repair, primary closure is still commonly performed during UHR, especially for smaller hernial defects, for which there is no sufficient published data to support any surgical approach [11]. In addition, many surgeons report technical difficulties when performing mesh repair in smaller defects, due to the difficult introduction of the mesh through a narrow space, which commonly raises concerns regarding the correct flattened placement of the material [23, 24].

Also, in smaller defects, the surgeon could cause intraoperative stretching and widening of the hernial orifice when introducing the mesh, raising concerns regarding postoperative repercussions, such as recurrence [5, 25]. In addition, some studies suggest that introducing a coated mesh

through the small orifice of a UH may cause deformation of the mesh, increasing the risk for adhesions and recurrence [26].

Kaufmann et al. [15] published an RCT in 2018, which comprised 284 patients. It compared outcomes between groups with mesh repairs and with primary closure in small umbilical hernial defects (1–2 cm). This study reported a 4.1% incidence of recurrence in the mesh repair group, compared to 12.3% with the suture repair. These results are similar to previous reports in the literature and to the overall analysis of recurrence in this meta-analysis, which also favored the mesh repair (3.4% vs. 7.3%). The sublay mesh positioning raises concerns regarding enlarging the hernia defect, especially for smaller hernias [25], however, Kaufmann et al. [15] included both sublay mesh repairs and small hernia defects (<2 cm) and showed significantly lower incidence of recurrence for the mesh repair group. In our study, when performing a subgroup analysis of sublay mesh repair and overall mesh positions there were significant differences between both groups, with lower incidence of recurrence in the mesh repair group for the sublay mesh placement ($P=0.003$), similar as the overall analysis.

Regarding seroma, hematoma, and wound infection, no differences were seen between both groups in Kaufmann et al. [15] study. These results are different from our pooled analysis, which identified higher rates of wound infection (4.6% vs. 3%) and seroma (5.9% vs. 3%) with the mesh repair in the overall analysis including both RCTs and observational studies. On the other hand, after performing a subgroup analysis including only RCTs, our study found no differences between mesh and suture regarding seroma and wound infection, which may provide better reliability considering the best study design and adjustment for confounders of the RCTs. Additionally, our pooled analysis for wound infection and seroma included all defect sizes, and subgroup analysis including only small umbilical hernia defects was not possible for these outcomes. When performing subgroup analysis of sublay mesh repair for wound infection, no differences were seen between mesh repair and primary suture repair. On the other hand, in the same subgroup analysis

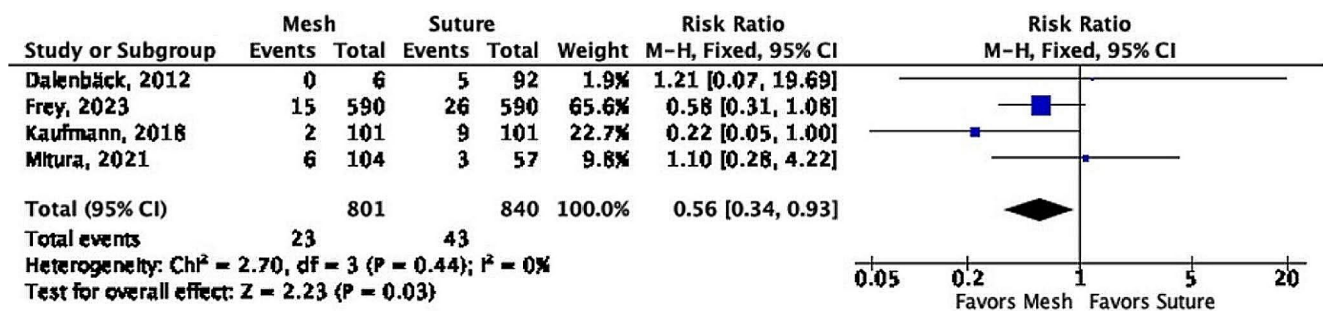


Fig. 6 Subgroup analysis of recurrence rates with hernia defects < 2 cm

for seroma, sublay mesh repair showed higher incidence of seroma compared to primary suture repair ($P=0.02$).

Frey et al. [27] recently published another important study, a propensity-matched score analysis of a cohort comprising 1180 patients, comparing mesh and suture repairs for umbilical hernias ≤ 1 cm regarding postoperative complications, such as wound infection and recurrence. This study reported a lower rate of recurrence in the mesh repair group (3.3% vs. 6.1%), similarly as reported by the previous studies on the topic and as in our subgroup analysis with hernias ≤ 2 cm, where it demonstrated a 2.9% incidence of recurrence in the mesh group compared with 5.1% with the suture repair.

The previous meta-analysis [16] published in 2020 comparing mesh repair with primary suture for UHR comprised several retrospective studies that didn't exclude recurrent hernias and emergency conditions, such as incarcerated or strangulated hernias. It raises concerns regarding the actual results for an elective primary UHR, since emergency conditions can generate tissue damage, increases inflammation and tissue necrosis, which increases the risk for wound infection and recurrence. Similarly, recurrent hernias may indicate previous weakness of the umbilical fascia and surrounding muscle fibers, also increasing the risk of recurrent failure of the repair. In addition, this meta-analysis didn't report subgroup analysis for smaller hernias, probably due to a lack of sufficient data regarding the hernia defect size.

The statistical analyses of the included outcomes showed lower heterogeneity between studies assessed when compared to the previous meta-analysis. Also, some inaccuracies previously reported were corrected in our study, such as the results from Berger et al. [28].

Nevertheless, it is important to highlight the limitations inherent in our analysis. Most of the included studies did not make a specific analysis for hernias with a 1 cm size. Despite being able to perform a subgroup analysis on hernias smaller than 2 cm, our study couldn't provide a specific analysis on hernia defects smaller than 1 cm due to lack of data, which maintains the existing gap in the literature regarding small umbilical hernias. On the other hand, our findings reinforce and provide strong evidence supporting the guidelines indications for the use of mesh for hernia defects > 1 cm. Additionally, a subset of the included studies received ratings denoting moderate risk of bias, implying potential methodological limitations in the overall analysis. Few studies included in our analysis reported in which abdominal wall layer the mesh was placed, and we were only able to do a subgroup analysis with sublay mesh placement, using the studies which reported this data. Lastly, this study was not able to assess patient related outcomes, such as pain, quality of life, and cosmesis related to the procedures performed due to insufficient data on these topics,

which highlights an existing gap in the literature. However, our analysis stands as the most recent synthesis of the available evidence concerning umbilical hernias, encompassing those with defects measuring less than 2 cm.

Conclusion

The use of mesh during UHR is associated with significantly lower risk of recurrence for all sizes of umbilical hernia defects. Additionally, the risk of seroma and wound infection, despite favoring the suture repair in the overall analysis, shows no significant differences between mesh and suture repair after assessing RCTs only.

Funding There was no funding for this manuscript.

Declarations

Ethical approval We prospectively registered our research protocol in the International Prospective Register of Systematic Reviews (PROSPERO) with ID number CRD42024476854. As this concerns a systematic review and meta-analysis study, no ethical approval or informed consent was required.

Informed consent Not applicable.

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