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# Favorable Outcomes After Retro-Rectus (Rives-Stoppa) Mesh Repair as Treatment for Noncomplex Ventral Abdominal Wall Hernia, a Systematic Review and Meta-analysis

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**Objective:** To assess prevalence of hernia recurrence, surgical site infection (SSI), seroma, serious complications, and mortality after retro-rectus repair.

**Summary Background Data:** Ventral abdominal wall hernia is a common problem, tied to increasing frailty and obesity of patients undergoing surgery. For noncomplex ventral hernia, retro-rectus (Rives-Stoppa) repair is considered the gold standard treatment. Level-1 evidence confirming this presumed superiority is lacking.

**Methods:** Five databases were searched for studies reporting on retro-rectus repair. Single-armed and comparative randomized and non-randomized studies were included. Outcomes were pooled with mixed-effects, inverse variance or random-effects models.

**Results:** Ninety-three studies representing 12,440 patients undergoing retro-rectus repair were included. Pooled hernia recurrence was estimated at 3.2% [95% confidence interval (CI): 2.2%–4.2%, n = 11,049] after minimally 12months and 4.1%, (95%CI: 2.9%–5.5%, n = 3830) after minimally 24 months. Incidences of SSI and seroma were estimated at respectively 5.2% (95%CI: 4.2%–6.4%, n = 4891) and 5.5% (95%CI: 4.4%–6.8%, n = 3650). Retro-rectus repair was associated with lower recurrence rates compared to onlay repair [odds ratios (OR): 0.27, 95%CI: 0.15–0.51, $P < 0.001$] and equal recurrence rates compared to intraperitoneal onlay mesh (IPOM) repair (OR: 0.92, 95%CI: 0.75–1.12, $P = 0.400$). Retro-rectus repair was associated with more SSI than IPOM repair (OR: 1.8, 95%CI: 1.03 –3.14, $P = 0.038$). Minimally invasive retro-rectus repair displayed low rates of recurrence (1.3%, 95%CI: 0.7%–2.3%, n = 849) and SSI (1.5%, 95%CI: 0.8%–2.8%, n = 982), albeit based on non-randomized studies.

**Conclusions:** Retro-rectus (Rives-Stoppa) repair results in excellent outcomes, superior or similar to other techniques for all outcomes except SSI. The latter rarely occurred, yet less frequently after IPOM repair, which is usually performed by laparoscopy.

**Keywords:** IPOM, mesh, onlay, recurrence, retro-rectus, Rives-Stoppa, ventral hernia repair

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Incisional and primary ventral abdominal wall hernia are common diseases, which account for over 348.000 surgical procedures each year in the United States. Moreover, despite increased use of minimally invasive surgery, numbers of ventral hernia repair procedures both in elective and emergency settings have not decreased.[1]

Although the natural development of ventral abdominal wall hernia has not been elucidated, ventral abdominal wall hernia is known to progress and may result in acute complications and mortality in case of incarceration.[2–4] Additionally, ventral abdominal wall hernia is associated with pain, discomfort, impaired cosmesis, and impaired quality of life.[5] Correctly performed elective treatment ameliorates these complaints and may prevent rarer sequelae of ventral abdominal wall hernia.

For all but the smallest ventral hernias, closure with mesh implantation is the gold standard.[6] Mesh repair can be performed with multiple techniques, usually defined based on the position of the mesh (Fig. 1). Incisionalherniaresearch is hampered by the unsystematic use of different techniques, mesh types, fixation techniques, and the use of open or laparoscopic surgery. This results in heterogeneous results, making interpretation difficult. Moreover, benchmark outcomes for recurrence, infections, and complications are lacking.

Nearly all medical specialists and generalists encounter patients with ventral hernia at some point in their practice. Since the implementation of mesh repair, many misconceptions circulate concerning risks, complications and expected outcomes associated with mesh prostheses. Therefore, providing the broader medical community, not just (hernia) surgeons, with the accurate and comprehensive information required to inform patients and provide proper referral is imperative.

For medium sized (European Hernia Society Classification W2, ≥4–10 cm), noncomplex ventral abdominal wall hernia, retro-rectus repair, as described by Rives and Stoppa, is one of the most widely applied techniques.[7–12] This technique is thought to be superior. However, accurate summary estimates of expected outcomes after retro-rectus repair concerning large and consecutive patient samples are lacking. Moreover, level-1 evidence, based on pooled estimates of randomized studies, confirming the presumed superiority of this technique is unavailable.

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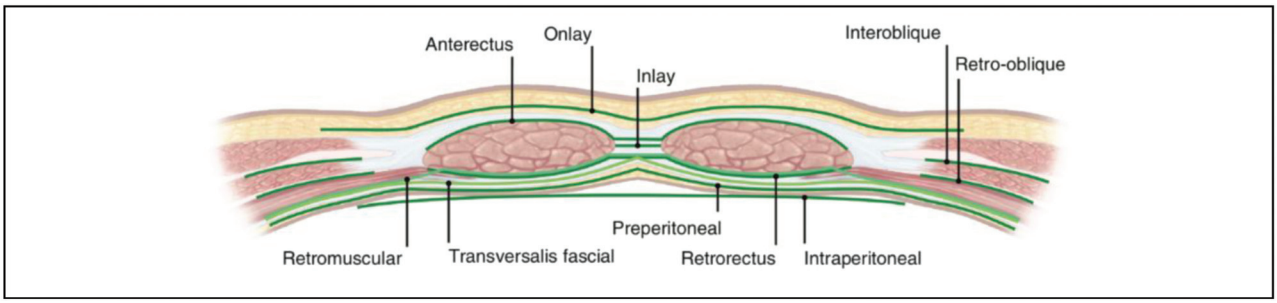



**FIGURE 1.** International classification of abdominal wall planes. Reused with permission.[14]

This systematic review and meta-analysis aims to assess the pooled outcomes of specifically retro-rectus repair in terms of recurrence, infections and incidence of severe complications. Additionally, outcomes after retro-rectus repair will be compared to other available techniques.

## METHODS

This systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[13] The study protocol was prospectively registered in the PROSPERO database with registration identifier CRD42018088247.

### Search Strategy

The Embase, Medline Ovid, Cochrane, Web of Science, and Google Scholar databases were searched for studies reporting specifically on retro-rectus (Rives-Stoppa) repair (Fig. 1).[14] Published records were identified through June 2021. The full search syntax is presented in the Online Supplements, http://links.lww.com/SLA/D680. Conference abstracts, reviews, case reports, letters and editorials, pediatric studies, and studies not written in English were excluded. Articles published in journals not registered by both Web of Science and Scopus were excluded. Single armed and comparative studies (retrospective and prospective) were both eligible for inclusion. In case studies presented data on a similar cohort of patients (duplicate cases), the most recent outcomes were considered. Initial study selection was performed based on title and abstract by two independent reviewers, disagreement was resolved by consensus. Subsequently, selected abstracts were evaluated based on full text. Articles not clearly describing retro-rectus dissection, describing a preperitoneal technique only, combining retro-rectus dissection with component separation techniques or not presenting results separately for the retro-rectus technique were excluded. Case series presenting fewer than 10 patients were excluded.

### Risk of Bias Assessment

A risk of bias assessment was performed for comparative studies by two independent reviewers, differences were resolved by consensus. Risk of bias was assessed with the Risk of Bias 2 tool for randomized trials[15] and with the Risk Of Bias In Non-randomized Studies of Interventions tool for non-randomized comparative studies.[16] Risk of bias was assessed separately for different outcomes, because the risk of bias may not be equal for all outcomes. Risk of bias was presented as separate columns in forest plots for individual studies and as stacked bar charts as an overview.

### Data Extraction

Extracted baseline characteristics comprised age, body mass index, sex, etiological hernia type (primary or incisional), whether the hernia was recurrent, hernia size (as reported, width, diameter, or area). Surgical characteristics comprised the type of mesh used and whether open or minimally invasive surgery was performed. Outcomes included: follow-up duration, hernia recurrence (after a minimum of 12 and 24 months follow-up), diagnostic modality used, surgical site infection (SSI), seroma formation, serious complications (Clavien-Dindo $\geq$ 3) and 30-day mortality.[17]

### Statistical Analysis

Statistical analysis was performed with R-statistics (version 4.01).[18] Aggregated continuous baseline characteristics were summarized by calculating the median of provided summary measures in included studies. Categorical baseline characteristics were summarized in absolute numbers and percentages. Pooled proportions of outcomes were calculated with mixed effects models, using a random intercept logistic regression model for all outcomes except for SSI, for which the inverse variance method was used because the logistic regression model did not converge for that outcome. Heterogeneity in outcomes was quantified with the $I^2$ statistic using the DerSimonian-Laird method. Pooled proportions were presented with a corresponding 95% confidence interval (95%CI) and a prediction interval. The prediction interval represents the estimate of an interval in which a single future observation will fall, given what has already been observed. Different outcomes of comparative studies were pooled with use of random effects models. Compared outcomes were presented as odds ratios (OR) with corresponding 95% CIs. A pooled OR was presented separately for randomized, non-randomized prospective, non-randomized retrospective, and all studies combined. Potential publication bias was assessed with funnel plots.

## RESULTS

### Literature Search Results

The PRISMA flow-chart is presented in Fig. 2. Out of 3335 unique records, 93 studies were included. These included 15 randomized trials, 36 prospective studies and 42 retrospective studies. Of these 93 studies, 43 studies were single-armed, non-comparative studies and 50 studies were comparative.

### Baseline Characteristics

Baseline characteristics are presented in the Supplemental Digital Content Table 1, http://links.lww.com/SLA/D680 and Supplemental Digital Content Table 2, http://links.lww.com/SLA/D680. In total, 18,572 patients were included with a male to female ratio of approximately 1 to 3. Median or mean age (as reported) ranged from 25 to 66.9 years (aggregated median 55 years). Median or mean body mass index (as reported) ranged from 17.7 to 39 kg/m$^2$ (aggregated median 29.7 kg/m$^2$). For patients undergoing retro-rectus repair, median or mean hernia diameter ranged from 3.9 to 23.5 cm

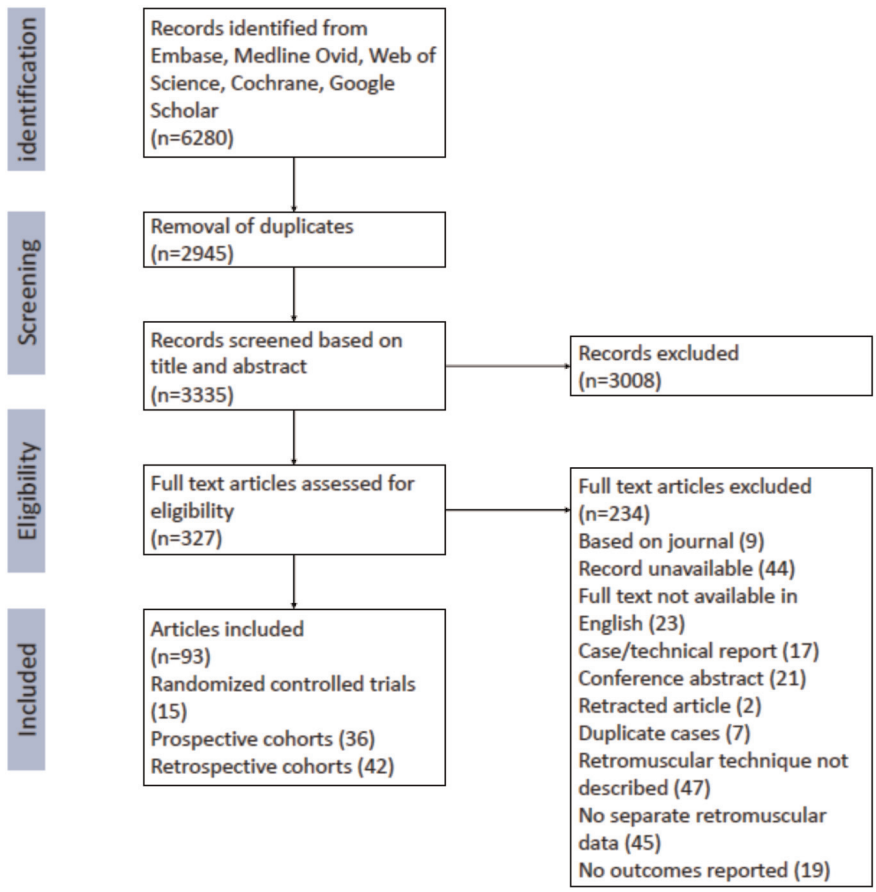



**FIGURE 2.** PRISMA flow-chart.

(aggregated median 7.2 cm) and mean or median hernia area ranged from 2.6 to 1690 $cm^2$ (aggregated median 67.15 $cm^2$). Median or mean follow-up duration (as reported) ranged from 1 to 112 months (aggregated median 17 months). Surgery for recurrent incisional hernia occurred in 1807 patients (9.7%) across 44 studies.[19–62] Results after minimally invasive (laparoscopic, robotic, or hybrid) retro-rectus repair were reported by 17 studies (n = 1516)[22,24,28,40,47,53,54,58,63–71] and results after open retro-rectus repair were reported by 78 studies (n = 10,924).[19–21,23,25–27,29–39,41–46,48–52,54–62,71–110] Recurrence was generally diagnosed by physical examination. Radiological modalities (ultrasound, Computed Tomography-scan or Magnetic Resonance Imaging-scan), if used, were only used in case of uncertainty. Systematic radiological evaluation was only performed in two studies.[93,110]

## Risk of Bias Assessment

Results of the risk of bias assessment are presented in Supplemental Digital Content Figure 1, http://links.lww.com/SLA/D680 and in all individual forest plots. For randomized studies, two studies (14%) had a serious risk of bias arising from the randomization process. One study inadequately described the randomization sequence used (merely stating ''the lottery method'') and did not mention any blinding procedure.[97] Another study did not report the specific randomization methodology and blinding procedures.[73] For non-randomized studies, the majority of studies were at risk for confounding (moderate risk: 71%, critical risk: 21%) or selection bias (moderate risk: 61%, critical risk: 32%). Additionally, most studies (89%) had a moderate risk of bias due to their aforementioned lack of systematic use of radiological diagnostic modalities. To assess the risk for publication bias, funnel plots are presented for all comparative outcomes including more than 5 studies in Supplemental Digital Content Figure 2, http://links.lww.com/SLA/D680. Asymmetry in the funnel plots, suggesting a potential risk for publication bias was present in the comparison of retro-rectus repair to onlay repair on the incidence of SSI and seroma.

## Overall Outcomes After Retro-rectus Mesh Repair

Outcomes after retro-rectus mesh repair are summarized in Fig. 3, the recurrence rate after a minimum of 12 months was 3.2% (95%CI: 2.4%–4.2%, 71 studies, n = 10,787) and after 24 months 4.1% (95%CI: 3.0%–5.6%, 36 studies, n = 3770). Serious complications and 30-day mortality, respectively, occurred in 2.7% (95%CI: 1.9%–4.0%, 42 studies, n = 4844) and 0.2% (95%CI: 0.1%–0.8%, 38 studies, n = 3650). Less severe complications including SSI and seroma respectively occurred in 5.2% (95%CI: 4.2%–6.5%, 71 studies, n = 7030) and 5.5% (95%CI: 4.4%–7.0%, 67 studies, n = 10,695). As is demonstrated in Supplemental Digital Content Figures 14, http://links.lww.com/SLA/D680, 15 and 16, when only considering studies that included recurrent incisional hernia patients and patients operated on a first hernia, the recurrence rate after a minimum of 12months was 3.7% (95% CI: 2.6%–5.2%, 41 studies, n = 4003). The rates of SSI and seroma were estimated at 5.2% (95% CI: 3.4%–7.7%, 29 studies, n = 2864) and at 6.1% (95% CI: 4.0%–9.1%, 29 studies, n = 2864).

## Retro-rectus Mesh Repair Versus Onlay Mesh Repair

Retro-rectus repair was compared to onlay mesh repair by 15 studies. Considering randomized studies only, retro-rectus repair was associated with a lower risk for hernia recurrence (OR: 0.33, 95%CI: 0.13–0.80, $P = 0.016$, 6 studies, n = 556), considering all studies this

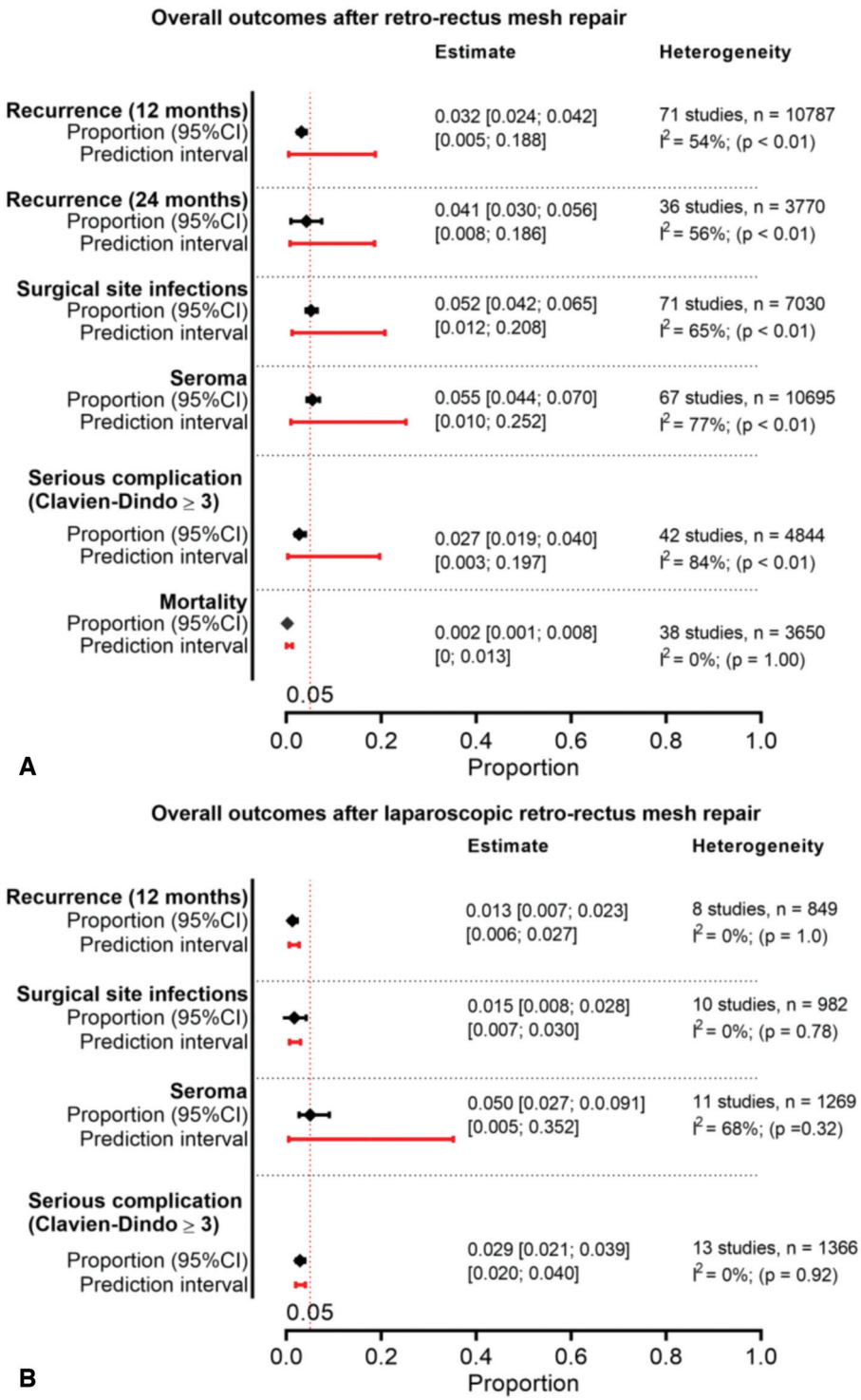
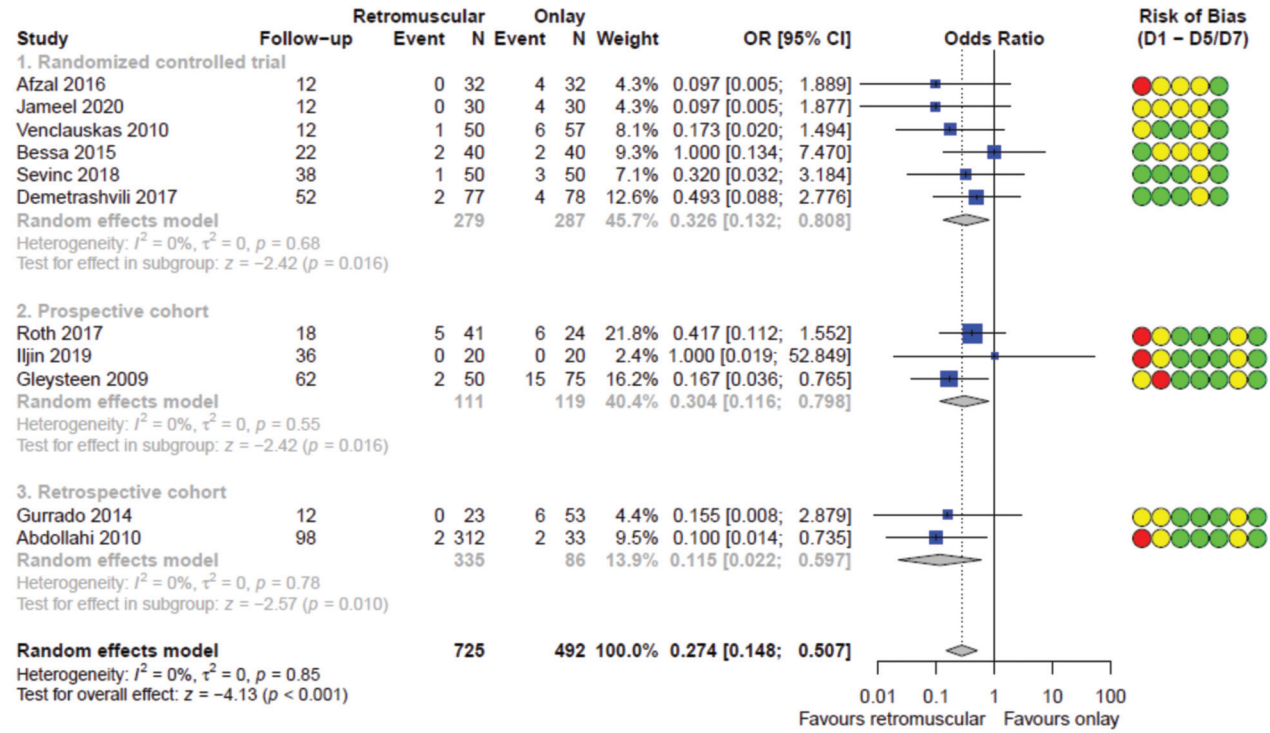



**FIGURE 3.** Overall outcomes after retro-rectus mesh repair (A) and minimally invasive retro-rectus mesh repair (B) Studies used per outcome (A): Recurrence (12 months):[19–21,23,25–30,32–39,41–46,48,50–55,57,58,60–62,64,68,70–78,80,82–95,98–101,103,105,107,109,110]. Recurrence (24months):[19–21,26,27,29,30,32,33,36–38,41–44,48,50,55,60,62,71,72,74,76,77,80,83–85,89,93,94,98,105,110]; Surgical site infection:[19–23,25–31,33–35,37–39,41–45,48–54,56,57,59–67,69,72–74,77–82,84–89,91,95–99,102,104–108,110,136]; Seroma:[19–23,25–34,36–42,44,45,47–50,52–54,56,57,63,64,66,67,69,72–74,76–82,84–92,95,96,98,100,102,104–107,110]; Serious complication (Clavien-Dindo ≥ **3);** [20,21,24,25,27,29–31,34,36–40,42,45,47–52,54,56,58,61,63–67,69–72,74,78,95,96,102,108,137] Mortality: [20,21,23–26,28,29,31–34,36,38,42,44,46,48–51,53,61,63,65–67,70–72,74,75,77,86,95,99,102,108]. Studies used peroutcome (B): Recurrence (12 months):[28,53,54,58,64,68,70,71]; Surgical site infection:[22,28,53,54,63–67,69] **Seroma:**[22,28,40,47,53,54,63,64,66,67,69]; Serious complication (Clavien-Dindo ≥ 3):[24,40,47,54,58,63–67,69–71]. Complete figures for each individual outcome are available in the Online Supplements, http://links.lww.com/SLA/D680.

effect remained similar (OR: 0.27, 95%CI: 0.15–0.51, $P < 0.001$, 11 studies, n = 1217) (Fig. 4).[33,72,73,78,84,87,89,90,103,105,107] Considering randomized studies only, retro-rectus repair was associated with a lower risk for SSI (OR: 0.41, 95%CI: 0.25–0.68, $P < 0.001$, 8 studies, n = 906), considering all studies this effect remained similar (OR: 0.40, 95%CI: 0.26–0.60, $P < 0.001$, 13 studies, n = 1632) (Fig. 5).[33,72,73,78,79,84,87,89,97,104–107] Considering randomized studies only, retro-rectus repair was associated with a lower risk for seroma (OR: 0.29, 95%CI: 0.18–0.45, P < 0.001, 8 studies, n — 866), considering all studies this effect remained similar (OR:



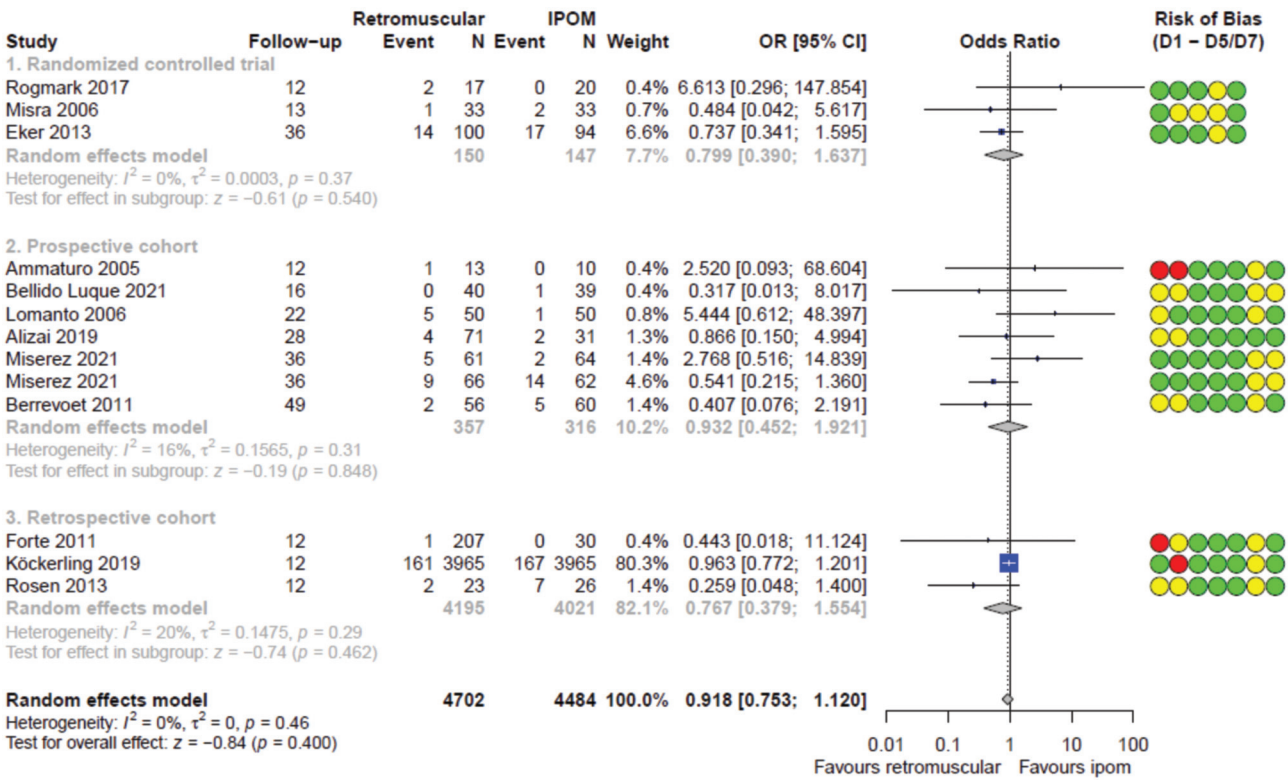




**FIGURE 4.** Recurrence after retro-rectus mesh repair versus onlay mesh repair (top) and retro-rectus mesh repair versus intraperitoneal onlay mesh repair (bottom). IPOM: intraperitoneal onlay mesh;OR: odds ratio;D1 – D5/D7: risk of bias domains.

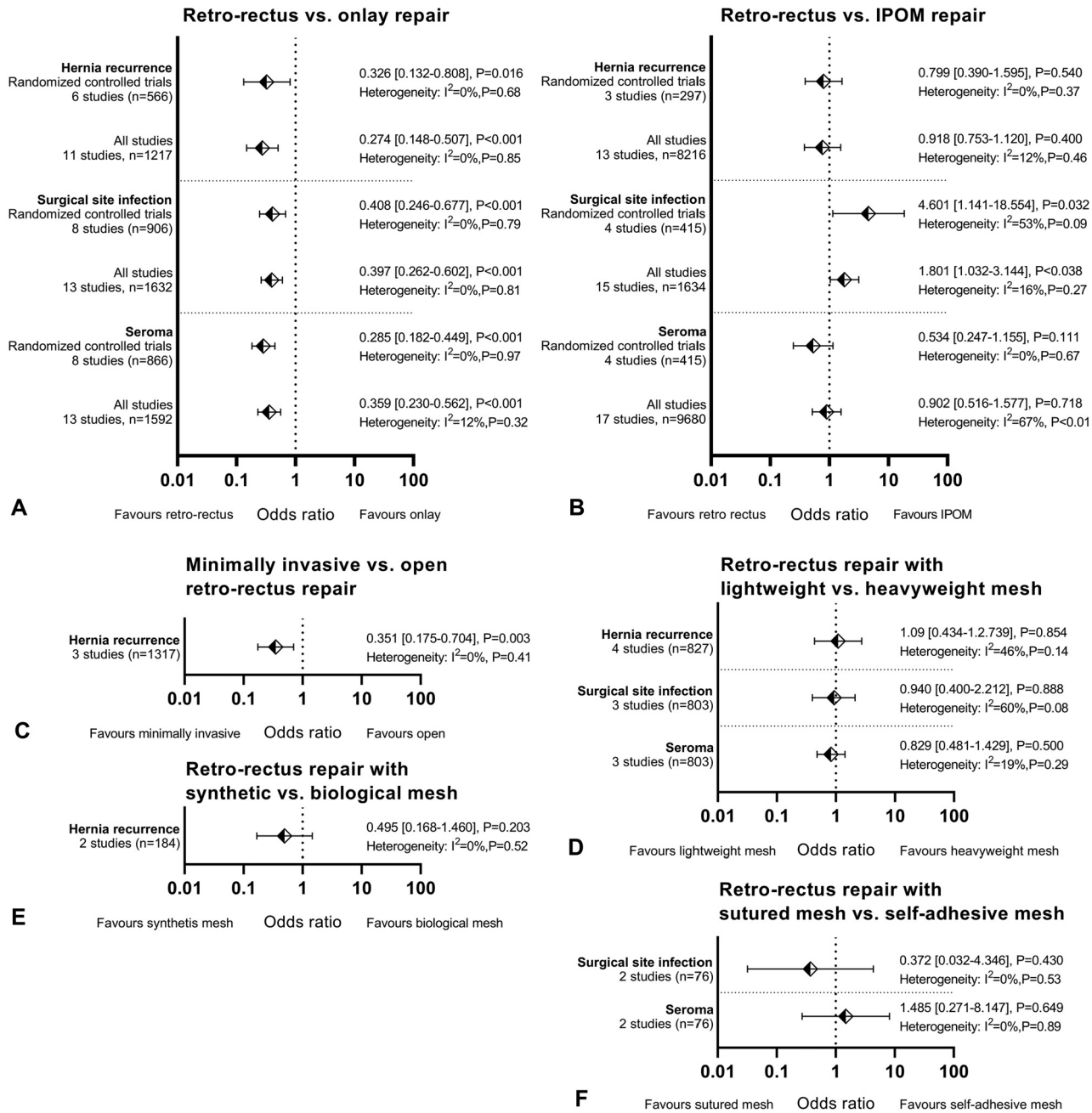



**FIGURE 5.** All comparative outcomes. IPOM: intraperitoneal onlay mesh. Full-size, detailed forest plots for all of the above outcomes are available in the Supplemental Digital Content Figures 3–13, http://links.lww.com/SLA/D680.

0.36, 95%CI: 0.23–0.56, P < 0.001, 13 studies, n = 1592) (Fig. 5).[33,72,73,78,79,84,87,89,97,104–107]

## Retro-rectus Mesh Repair Versus Intraperitoneal Onlay Repair

Retro-rectus repair was compared to intraperitoneal onlay mesh repair by 19 studies. Considering randomized studies only, retro-rectus repair was associated with an equal risk for hernia recurrence (OR: 0.80, 95%CI: 0.39–1.64, P = 0.540, 3 studies, n = 297), considering all studies this effect remained similar (OR: 0.92, 95%CI: 0.75–1.12, P = 0.400, 13 studies, n = 8216) (Fig. 5).[30,39,44,45,57,64,74–76,86,92,101] Considering randomized studies only, retro-rectus repair was associated with an increased incidence of SSI (OR: 4.6, 95%CI: 1.14–18.54, P = 0.032,4 studies, n = 415), considering all studies this effect remained significant (OR: 1.8, 95% CI: 1.03–3.14, P = 0.038, 15 studies, n = 1634) (Fig. 5).[30,31,39,44,45,56,57,63,64,69,74,81,86,96,102] Considering randomized studies only, retro-rectus repair was associated with an equal risk for seroma (OR: 0.53,95%CI: 0.25–1.16, P < 0.111,4 studies, n = 415), considering all studies this effect remained similar (OR: 0.90, 95%CI: 0.52–1.58, P = 0.718, 17 studies, n = 9680) (Fig. 5).[30,31,39,44,45,56,57,63,64,69,74,76,81,86,92,96,102]

### Retro-rectus Versus Preperitoneal Repair

One study compared retro-rectus (n = 68) to preperitoneal repair (n = 92).[85] In this study, propensity score matching was used to match patients who underwent retro-rectus repair to patients who underwent preperitoneal repair. Nine patients in the retro-rectus group (13%) had a recurrence aftera mean follow-up of42.6 months. Eleven patients in the preperitoneal group (12%) had a recurrence after a mean follow-up of 35.9 months. This difference was not statistically significant (P = 0.33), and neither were differences in SSI or seroma formation.

### Minimally Invasive Versus Open Retro-rectus Repair

Minimally invasive retro-rectus repair was associated with a lower incidence of recurrence compared to open retro-rectus repair (OR 0.35, 95%CI: 0.18–0.70, P = 0.003, 3 studies, n = 1317).[58,71,92] No studies compared the incidence of SSI, seroma, or serious complications. Overall non-comparative results of minimally invasive retro-rectus repair are summarized in Fig. 3. The recurrence rate after 12months was 1.3% (95%CI: 0.7%–2.3%, 8 studies, n = 849).[28,53,54,58,64,68,70,71] Serious complications occurred in 2.9% (95%CI: 2.1%–3.9%, 13 studies, n = 1366),[40,47,54,58,63–67,69,70,71,111–113] data on mortality was not reported. Less severe complications including SSI and seroma respectively occurred in 1.5% (95%CI: 0.8%–2.8%, 10 studies, n = 982)[22,28,53,54,63–67,69] and 5% (95%CI: 2.7%–9.1%, 11 studies, n = 1269).[22,28,40,47,53,54,63,64,66,67,69]

### Outcomes After Retro-rectus Repair With Different Mesh Types or Fixation Techniques

No significant difference was present on the risk for recurrence between heavyweight and lightweight mesh (OR 1.09, 95%CI: 0.43–2.74, P = 0.14, 4 studies, n = 827) (Fig. 5).[27,77,93,110] Additionally, no significant difference was present concerning SSI (OR 0.94, 95%CI: 0.40–2.21, P = 0.888, 3 studies, n = 803) or seroma (OR 0.83, 95%CI: 0.48–1.43, P = 0.500, 3 studies, n = 803) (Fig. 5).[27,77,110] No significant difference was present in the incidence of hernia recurrence between synthetic and biological mesh (OR 0.5, 95%CI: 0.168–1.460, P = 0.203, 2 studies, n = 184) (Fig. 5).[44,109] Additionally, no significant difference was present for SSI (OR 0.63, 95%CI: 0.144–2.76, P = 0.802, 1 study, n = 127), but a lower rate of seroma was reported in the synthetic group (OR 0.221, 95%CI: 0.077–0.64, P = 0.006, 1 study, n = 127).[44] Hernia recurrence after retro-rectus repair with a mesh fixed with sutures versus self-adhering mesh was compared in two studies, however no recurrent hernia was reported in either group.[25,91] Additionally, no significant difference was present concerning SSI (OR: 0.37, 95%CI: 0.032–4.346, P = 0.430, 2 studies, n = 76) or seroma (OR: 1.49, 95% CI: 0.271–8.147, P = 0.649, 2 studies, n = 76) (Fig. 5).

## DISCUSSION

Based on pooled estimates of reported outcomes, retro-rectus repair according to the Rives-Stoppa technique was usually associated with favourable outcomes. Recurrence rates after a minimum follow-up of 24 months were low and would likely facilitate a clear treatment benefit for most patients. SSI and seroma formation occur infrequently. Moreover, severe complications were rarely reported and 30-day mortality rates did not exceed risks which are generally associated with surgical procedures under general anaesthesia.[114,115]

Retro-rectus repair was associated with a substantial benefit when compared to onlay mesh repair. Onlay mesh repair was associated with both a 3.7-fold increase in hernia recurrence and an increased incidence of SSI and seroma. Compared to intraperitoneal onlay repair, recurrence rates were similar. However, intraperitoneal onlay repairwas associated with a lowerincidence of SSI. The latter is likely explained by the fact that intraperitoneal onlay repair is usually performed by laparoscopic or robotic surgery, leading to fewer wound related complications.[116] Unfortunately, data on the relatively novel minimally invasive retro-rectus repair techniques is still limited. Based on available data, minimally invasive retro-rectus repair is associated with equally low rates of SSI compared to intraperitoneal onlay repair. Based on three non-randomized studies, minimally invasive retro-rectus repair showed significant and clinically relevant reduction in recurrence rate compared to open retro-rectus repair.[58,71,92] However, these findings have yet to be validated in randomized studies. Preperitoneal repair was only compared to retro-rectus repair in one study, therefore, superiority of either technique cannot be confirmed.[85]

Different mesh types and mesh fixation techniques used for retro-rectus repair are infrequently studied. No superiority of a specific mesh type or fixation technique was identified. The use of a biological mesh was assessed in one randomized study which was concluded prematurely due to a high rate of recurrence in the biological mesh group.[44] Although this difference did not reach statistical significance for the retro-rectus repair subgroup, a near two-fold increased recurrence rate was reported after retro-rectus repair with a biological mesh, after a follow-up of up to 36 months. Additionally, biological mesh is associated with much higher costs compared to conventional prosthesis.[117]

State of the art hernia research often focuses on technical developments, novel mesh types, fixation techniques, and preoperative conditioning. However, as identified by the present study, one of the most important factors determining results is the applied surgical technique. Technical developments should be assessed for one specific surgical technique.

An infrequently identified factor which has a major effect on recurrence rate is the diagnostic modality used.[118] Although systematic radiological follow-up with use of ultrasound is recommended to assess the incidence of hernia recurrence, these follow-up schemes are only rarely performed, likely due to associated costs and patient burden. The majority of studies only used radiological assessment in case of inconclusive physical examination. Based on prior research, this could result in up to approximately two times lower observed hernia recurrence rates.[118] Based on present data, this would constitute to actual average recurrence rates of up to approximately 6% and 8% after, respectively, 12 and 24 months follow-up, which would still be acceptable. Moreover, one previous study suggested that a hernia detected solely by radiology is often asymptomatic and thus clinically irrelevant.[119]

Although the average rates of complications and recurrence after retro-rectus repair are low, this does not necessarily apply to all patient groups. This is demonstrated by large prediction intervals and heterogeneity present in pooled analyses. Patients with known patient related risk factors such as obesity and smoking, patients who developed infection post-surgery or who underwent surgery in an emergency setting have a higher associated risk of up to approximately 20% for recurrence. These patients should be counselled appropriately.[120–123] Unfortunately, accurately validated models to quantify these risks are unavailable to date.[124]

Intraperitoneal onlay mesh repair was associated with fewer SSIs and equal hernia recurrence risk compared to retro-rectus repair. Therefore, potential advantages of this technique must not be excluded, especially when a minimally invasive technique is preferred. Based on present data, intraperitoneal mesh placement was not associated with increased occurrence of serious complications. Nevertheless, some controversy remains concerning placement of foreign materials within the abdominal cavity, as rare adverse events which could influence clinical decision making will potentially not

be captured well by interventional studies with predominantly smaller sample sizes and relatively short follow-up. In theory, intra-abdominal mesh placement could lead to increased formation of adhesions which could in turn lead to problems such as an obstructive ileus or fistulation. Data on these complications is unfortunately limited. In some observational studies, intra-peritoneal mesh placement was associated with substantial adhesion formation, however, no standardized metric exists to measure adhesions and in these same studies, measured adhesions appeared not to result in major clinical consequences in the majority of patients.[125–132] Additionally, induction of adhesions is not limited to intraperitoneal mesh placement, but may also be of concern for retrorectus repair.

Based on current data, preference for either technique cannot be definitively established. The retro-rectus technique provides a protected plane and will provide some medialization of the rectus sheath, which constitutes some theoretical advantages. However, the intraperitoneal technique may provide a technically less demanding minimally invasive approach, which could be desired in specific patients, and results in less SSIs. Regardless of the technique used, placement of any prosthetic foreign materials requires continuous monitoring to identify potential rare adverse events. The increased risk for SSI associated with retro-rectus repair as compared to intraperitoneal onlay repair may be considered acceptable when preferring a protected anatomical plane, when an open approach is required, when requiring medialization, or when additional component separation may be necessary. In absolute terms, the incidence of SSI after retro-rectus repair was estimated to be relatively low, occurring in approximately one in every twenty patients. Moreover, in the majority of cases, these infectious complications may be of relatively mild nature, treatable during the postoperative course without surgical intervention.[133] Unexpectedly, the higher incidence of postoperative infection did not lead to more recurrence when compared to intraperitoneal onlay mesh repair.

The marked increase in SSI associated with retro-rectus repair as compared to intraperitoneal onlay repair is likely caused by the open nature of retro-rectus repair. Minimally invasive retro-rectus repair techniques are novel, but have shown promising results in recent observational series, seeming to reduce both the complication and recurrence risk.[22,24,28,40,47,53,54,58,63–71] Minimally invasive retro-rectus repair may, therefore, be the next step forward for (incisional) hernia repair. However, evaluation in large adequately powered randomized trials is warranted.

Considering the present results, retro-rectus repair may be considered the optimal open treatment for medium-sized, noncomplex ventral abdominal wall hernia, associated with low recurrence rates and low risks for adverse events. It should be noted that complex ventral hernia repair (contaminated environment or giant hernias) may benefit from using different techniques, allowing for a technically less demanding laparoscopic approach or including additional component separation. From a technical perspective, retro-rectus repair will provide medialization of the rectus sheath, and may be extended with either anterior or posterior component separation when tension free closure is not possible.[134,135] Therefore, open ventral hernia repair should preferably be performed with retro-rectus mesh (Rives-Stoppa) repair, whereas other techniques may be reserved as salvage techniques in case of recurrence or in case retro-rectus repair is not possible due to anatomical or patient related concerns.

### Limitations

The present meta-analysis has several limitations, and methodological concerns in included studies were frequently identified. A risk for publication bias was identified on two compared outcomes. Due to a lack of systematic radiological evaluation, absolute recurrence rates are underestimated. Event rates in observational studies may be lower as compared to prospective or randomized studies, including systematic follow-up procedures as opposed to clinical follow-up. This was confirmed by sensitivity analyses (Supplemental Digital Content Figure 17, http://links.lww.com/SLA/D680 and Supplemental Digital Content Figure 18, http://links.lww.com/SLA/D680). Most included studies did not adequately report on mortality. When not reported, absence of mortality could not be assumed, therefore, the risk for associated mortality might have been overestimated. A risk for selection bias was identified in part of the comparative cohorts. Clinical selection of patients may have played a role in the obtained results of observational cohorts, potentially resulting in lower event rates. No sensitivity analysis was performed based on results of the risk of bias analysis. Most studies showed a risk of bias in the same quality domain (predominantly related to the use of radiological examination and patient selection). Therefore, it is difficult to provide a meaningful stratified analysis with sufficient numbers of patients included. Functional outcomes after ventral hernia repair, for example those related to cosmesis, daily activities, pain, and quality of life, are increasingly important parameters to assess treatment effectivity. These outcomes were not captured by the present study. Due to analysis of aggregated data, identification of treatment effects of specific subgroups or of additional risk factors was not possible.

Potential complications specific to the retro-rectus technique are posterior sheath breakdown, rectus denervation resulting in lateral bulge and violation of the semilunar line resulting in a lateral hernia. These are more often observed after transversus abdominis release and were rarely (ie, in virtually no study) reported. As such, we are unable to estimate their incidence or further consequences. We may assume that either these complications occur rarely, or are rarely captured in current clinical follow-up, due to losses or follow-up or failure to recognize and document these problems adequately. Overall rates of major complications leading to re-intervention were included in the analysis and occurred infrequently.

There is some heterogeneity in how retro-rectus mesh repair is performed, for example in the size of the cranio-caudal and medio-lateral dissections, mesh fixation techniques, types of mesh, mesh overlap (ie, magnitude of lateral dissection), closure technique (small bites and large bites), and dissection and/or use of the hernia sac. Despite this heterogeneity, which will be present across all included studies, the primary anatomical principle of using the retro-rectus plane shows favorable long-term and short-term outcomes.

## CONCLUSIONS

Considering pooled estimates, retro-rectus repair according to the Rives-Stoppa technique for ventral hernia was associated with favourable postoperative and long-term outcomes. Retro-rectus repair was superior to onlay mesh repair regarding all objectified outcomes. Intraperitoneal onlay mesh repair showed fewer SSIs but a comparable hernia recurrence rate, likely due to its minimally invasive nature. Minimally invasive retro-rectus repair might be the next major step forward in ventral hernia repair. Adequately powered randomized trials comparing open to minimally invasive retro-rectus repair are required to demonstrate its potential superiority. Initial, open ventral hernia repair should preferably be performed with use of the retro-rectus technique, whereas other techniques may be reserved as salvage techniques in case of recurrence or for patients for whom retro-rectus repair is not possible.

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