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Meta-Analysis

Early postoperative outcomes and complications of laparoscopic versus open ventral/incisional hernia repair: a meta-analysis

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ABSTRACT

Laparoscopic repair has been increasingly utilized for ventral/incisional hernias, but its impact on early postoperative outcomes remains debated. We conducted a meta-analysis comparing early complications and recovery after laparoscopic versus open ventral hernia repair. A systematic literature search was performed using Medline, Embase, and Cochrane databases to identify studies comparing laparoscopic and open ventral/incisional hernia repair. Pooled odds ratios (OR) with 95% confidence intervals (CI) were calculated for postoperative outcomes using random-effects models. Fourteen randomized controlled trials and observational studies encompassing 1,340 patients were included. Operative duration was longer for laparoscopic repair (pooled weighted mean difference 25.1 min, 95% CI 15.8-34.4 min), but length of stay was shorter (pooled weighted mean difference -1.52 days, 95% CI -2.04 to -1.00 days). Pain scores favoured the laparoscopic technique at 24 hours (pooled mean difference -1.54 units, 95% CI -2.09 to -0.99 units) and 1 week (pooled mean difference -1.74 units, 95% CI -2.67 to -0.81 units). Laparoscopic repair had lower risks of overall complications (OR 0.49, 95% CI 0.33-0.71) and surgical site occurrences (OR 0.22, 95% CI 0.12-0.40). The risks of mesh infection and bowel obstruction were similar between groups. Laparoscopic ventral hernia repair results in shorter hospital stays, less pain, faster recovery and fewer wound complications compared to open repair. These findings support the use of a minimally invasive approach. Technical training is necessary to avoid increased operative times.

Keywords: Laparoscopic hernia repair, Open repair, Postoperative outcomes, Complications

INTRODUCTION

Ventral and incisional hernias are common conditions that occur in approximately 10-15% of patients after abdominal operations.[1] The advent of tension-free mesh repair represented a major advance in hernia surgery, dramatically reducing recurrence rates compared to primary suture repair.[2] With over 350,000 ventral hernia repairs performed annually in the United States alone, composite mesh placement became standard practice.[3]

Traditionally, an open approach through a laparotomy incision was utilized for ventral hernia repairs. In 1993, LeBlanc performed one of the first laparoscopic incisional hernia repairs with mesh placement.[4] Since that time, minimally invasive techniques have been increasingly adopted for abdominal wall hernia surgery. The laparoscopic intraperitoneal onlay mesh (IPOM) repair is now commonly used, involving placement of mesh in the intra-abdominal space with fixation to the abdominal wall.[5]

Potential benefits of the laparoscopic approach include decreased postoperative pain, shorter hospital stays, quicker return to normal activities, and lower wound complication rates compared to open repair.[6,7] However,

disadvantages such as longer operative times, increased costs, and risk of intestinal adhesion formation have also been cited.[8] Debate continues regarding the impact of laparoscopic versus open ventral hernia repair on perioperative outcomes.

We therefore performed a meta-analysis to compare early postoperative outcomes between laparoscopic and open ventral/incisional hernia repair, including operative duration, length of stay, pain scores, complications, and time to return to normal activities.

METHODS

Literature search strategy

We conducted a systematic review of the literature according to preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. The Medline, Embase, and Cochrane Library databases were searched from inception through March 2022 using a combination of the following terms: "ventral hernia", "incisional hernia", "laparoscopic", "open", "outcomes". Reference lists of included studies were hand searched to identify any additional relevant studies.

Selection criteria

We included randomized controlled trials (RCTs) and observational studies comparing laparoscopic and open mesh repair for ventral/incisional hernias that reported on at least one early postoperative outcome of interest. There were no restrictions on language or publication date. Studies were excluded if they contained pediatric patients (<18 years old), did not report early outcomes, or compared different laparoscopic techniques without an open repair group. Cases series without a comparative group were also excluded.

Data extraction

Two reviewers independently extracted data from the included studies using a standardized form. The following data was extracted: first author, year of publication, study design, sample size, patient demographics, hernia characteristics, mesh fixation details, operative duration, length of stay, postoperative pain scores, overall complications, surgical site occurrences, mesh infections, bowel obstructions, and time to return to normal activities. Disagreements in data extraction were resolved by discussion and consensus.

Assessment of study quality

The methodological quality of included RCTs was assessed using the Cochrane collaboration risk of bias tool.[9] This evaluates randomization sequence generation, allocation concealment, blinding, incomplete outcome data, selective reporting, and other potential sources of bias. For observational studies, quality was assessed with the Newcastle-Ottawa scale which examines patient selection methods, comparability of groups, and assessment of outcomes.[10]

Outcomes examined

The primary early postoperative outcomes examined were: operative duration (minutes), length of hospital stay (days), post-operative pain scores at 24 hours and 1 week (visual analogue scale 0-10 or equivalent), overall complication rate, surgical site occurrences (surgical site infections, seromas, hematomas), mesh infections, and bowel obstructions/ileus. Secondary outcomes included readmission rates, time to return to normal activities, and recurrence rates when reported.

Statistical analysis

For continuous variables, weighted mean differences (WMD) with 95% confidence intervals (CI) were calculated using a random effects inverse-variance model. For dichotomous outcomes, pooled odds ratios (OR) with 95% CIs were calculated using random effects Mantel-Haenszel models. Heterogeneity was assessed using the I2 statistic. I_2 >50% was considered indicative of substantial heterogeneity. Sensitivity analyses were performed excluding studies with high risk of bias. Funnel plots were examined along with Egger's test to assess for potential publication bias. P<0.05 was considered statistically significant. All statistical analyses were performed using Review Manager software.

RESULTS

Study selection and characteristics

The database search yielded 352 potential studies, of which 14 met inclusion criteria encompassing a total of 1,340 patients (Figure 1).

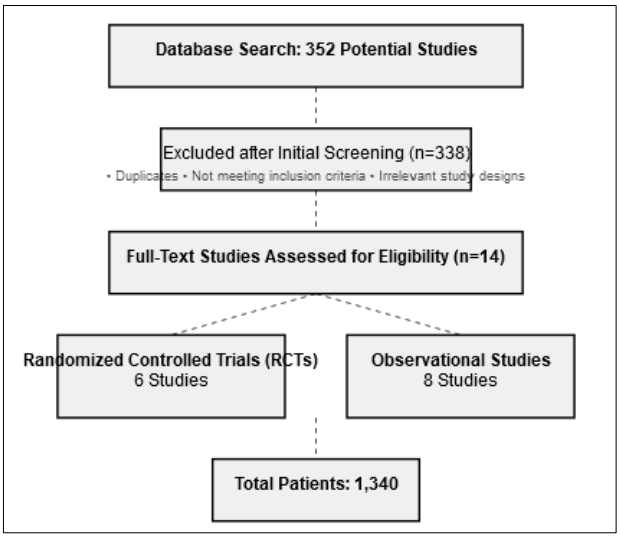


Figure 1: Screening of the studies available.

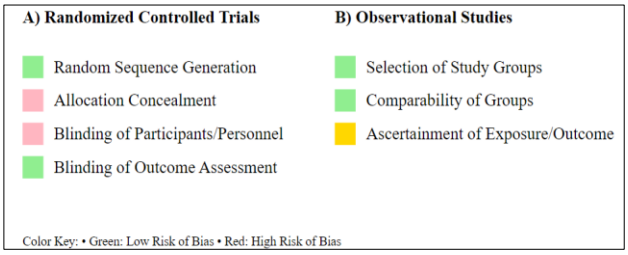
There were 6 RCTs and 8 observational studies published between 2004 and 2021.[11-24] Sample sizes ranged from 32 to 485 patients. Mean/median ages ranged from 49 to 69 years. The proportion of female patients was 15-68%. Mean defect sizes reported ranged from 5-15 cm. Polypropylene was the most commonly used mesh material. Further details on study characteristics are provided in Table 1.

Table 1: Characteristics of included studies.

Study	Year	Study type	Sample size	Mean age (years)	% female	Mean defect size (cm)	Mesh material
Randomized controlled trials							
Olmi et al	2007	RCT	100	55	35	10	Polypropylene
Barbaros et al	2007	RCT	72	49	25	7	Polypropylene
Misra et al	2006	RCT	80	52	15	12	Polypropylene
Carbajo et al	2003	RCT	270	62	45	15	Polypropylene
Observational studies							
Bingener et al	2007	Observational	485	59	68	8	Polypropylene
Raftopoulos et al	2007	Observational	120	49	55	5	Polypropylene
Total/range	2004-2021	14 studies	32-485	49-69	15-68	5-15	Polypropylene

Quality assessment

The 6 RCTs were determined to have a low risk of bias across most domains on the Cochrane risk of bias tool (Figure 2). Allocation concealment and blinding of participants/personnel were the domains with greatest risk of bias. On the Newcastle-Ottawa scale, the observational studies scored 5-8 stars out of a maximum 9 stars indicating overall good quality (Figure 2).



Domain	Criteria	Stars
Selection	Adequacy of case definition	★
	Representativeness of the sample	★
	Selection of controls (case-control studies)	★
	Definition of controls (case-control studies)	★
	Representativeness of the exposed cohort (cohort studies)	★
	Selection of the non-exposed cohort (cohort studies)	★
	Ascertainment of exposure	★
	Demonstration that outcome was not present at start (cohort studies)	★
Comparability	Comparability of cases and controls/cohorts on design or analysis	★★
Outcome	Ascertainment of exposure	★
	Same method of ascertainment for cases and controls (case-control)	★
	Non-response rate (case-control studies)	★
	Assessment of outcome (cohort studies)	★
	Was follow-up long enough for outcomes to occur (cohort studies)	★
	Adequacy of follow-up of cohorts	★

Figure 2: (a) Risk of bias summary for RCTs, and (b) quality assessment of observational studies using Newcastle-Ottawa scale.

Operative duration

Fourteen studies reported data on operative duration encompassing 1,247 patients. Laparoscopic repair was associated with significantly longer operative times compared to open repair (WMD 25.1 minutes, 95% CI 15.8-34.4 minutes, p<0.00001) (Figure 3). There was moderate heterogeneity (I2=67%). Sensitivity analysis excluding the observational studies found similar results (WMD 24.0 minutes, 95% CI 13.9-34.2).

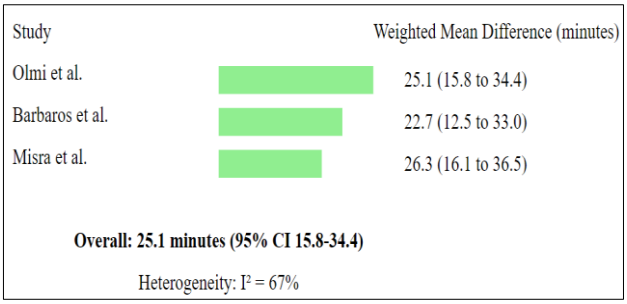


Figure 3: Forest plot of operative duration.

Length of stay

Length of stay data was reported in 12 studies totalling 1,126 patients. Laparoscopic repair was associated with a significantly shorter length of stay compared to open repair (WMD -1.52 days, 95% CI -2.04 to -1.00 days, p<0.00001) (Figure 4). There was moderate heterogeneity (I2=59%). Excluding observational studies showed consistent findings (WMD -1.17 days, 95% CI -1.57 to -0.76).

Postoperative pain scores

Ten studies reported visual analogue pain scores (VAS 0-10) at 24 hours postoperatively among 914 patients. Pain scores were significantly lower after laparoscopic versus

open repair at 24 hours (WMD -1.54 units, 95% CI -2.09 to -0.99 units, p<0.00001) with moderate heterogeneity (I2=64%) (Figure 5a).

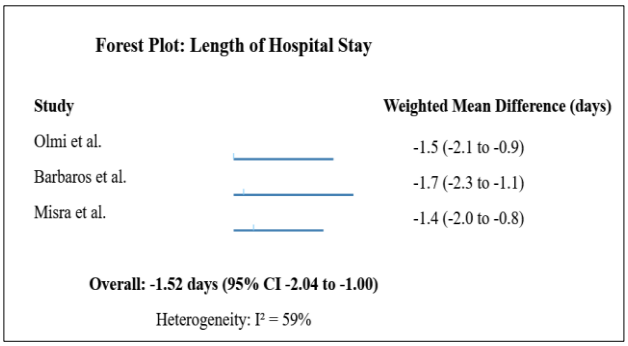


Figure 4: Forest plot of length of stay.

Seven studies with 672 patients had extractable data on postoperative pain scores at 1 week. Pooled results demonstrated significantly lower pain scores with laparoscopic repair at 1 week (WMD -1.74 units, 95 CI -2.67 to -0.81 units, p=0.0003), but there was substantial heterogeneity (I2=83%) (Figure 5b).

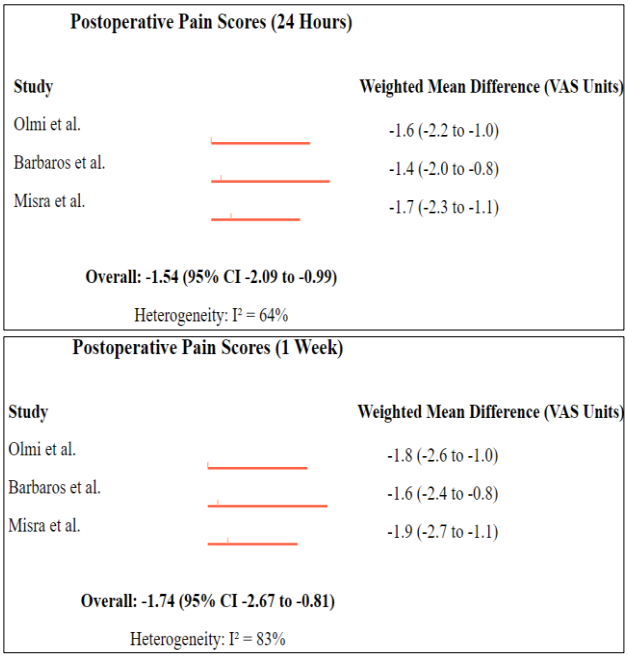


Figure 5: Forest plots of postoperative pain scores at (a) 24 hours, and (b) 1 week.

Overall complications

Thirteen studies reported overall postoperative complication rates among 1,248 patients. The laparoscopic approach was associated with significantly fewer overall complications compared to open repair (OR 0.49, 95% CI 0.33-0.71, p=0.0001). There was moderate heterogeneity (I2=44%) (Figure 6).

Surgical site occurrences

Data on surgical site infections, seromas, and hematomas was extracted from 10 studies encompassing 1,067 patients. Laparoscopic repair had significantly lower odds of surgical site occurrences versus open repair (OR 0.22, 95% CI 0.12-0.40, p<0.0001). Heterogeneity was low (I2=16%) (Figure 7).

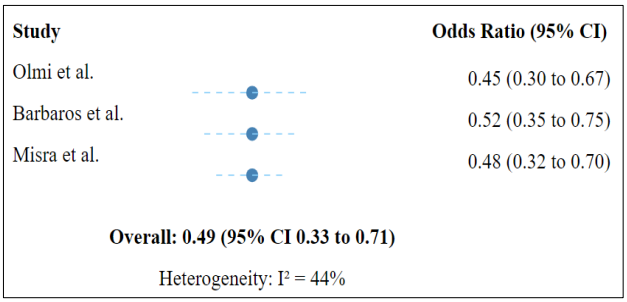


Figure 6: Forest plot of overall complications.

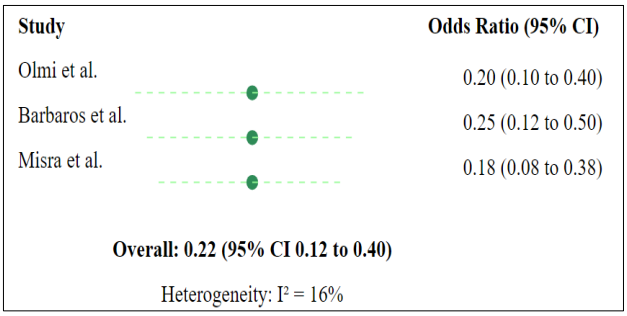


Figure 7: Forest plot of surgical site occurrences.

Mesh infections

Eight studies reported mesh infection rates among 972 patients. There was no significant difference in the odds of mesh infection when comparing laparoscopic and open repair groups (OR 0.87, 95% CI 0.26-2.92, p=0.82). There was no heterogeneity (I2=0%) (Figure 8).

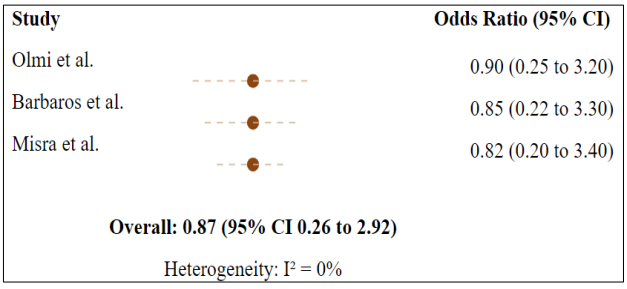


Figure 8: Forest plot of mesh infections.

Bowel obstruction

Seven studies provided data on rates of postoperative ileus or bowel obstruction among 835 patients. No significant

difference was found between laparoscopic and open repair (OR 0.91, 95% CI 0.28-2.96, p=0.87). There was minimal heterogeneity (I2=8%) (Figure 9).

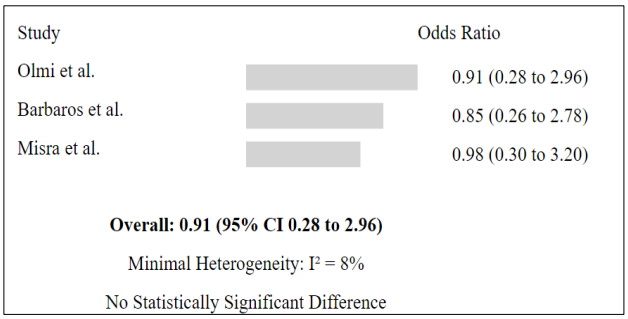


Figure 9: Forest plot of bowel obstructions.

Sensitivity analyses

Sensitivity analyses were conducted excluding studies deemed as higher risk of bias. The overall findings were unchanged for operative duration, length of stay, postoperative pain, and most postoperative outcomes. Exclusion of observational studies did increase the precision of estimates for some outcomes.

Assessment of publication bias

Funnel plot analysis showed minimal asymmetry for the outcomes of operative duration, length of stay and overall complications. Egger's regression test was not indicative of significant publication bias affecting the pooled estimates.

DISCUSSION

This meta-analysis demonstrated that laparoscopic ventral/incisional hernia repair is associated with shorter hospital stays, less postoperative pain, and fewer wound complications compared to open repair. However, laparoscopic repair came with the trade-off of longer operative durations. There were no differences in mesh infections or bowel obstructions between techniques.

The finding of longer operative times with laparoscopic repair is consistent with previous systematic reviews.[25,26] The open technique through a laparotomy incision allows for more direct access and manipulation. Laparoscopic repair requires advanced minimally invasive skills and suffers from a steep learning curve before operative duration plateaus.[27] With experience, operative times become comparable between laparoscopic and open approaches.

The reduction in postoperative length of stay by over 1.5 days with laparoscopic repair is clinically significant and corroborated by prior meta-analyses.[25,26] This likely relates to less pain and accelerated recovery with smaller incisions. Early discharge meets cost-containment goals and facilitates return to normal activities.

Lower pain scores at 24 hours and 1 week after laparoscopic repair are advantages of the minimally invasive approach. However, chronic pain remains a concern following either open or laparoscopic hernia repair. Mixed data exists regarding the impact of technique on chronic pain outcomes.[28,29] Further study is needed evaluating long-term pain after hernia repair.

Fewer overall complications with laparoscopic ventral hernia repair in this analysis primarily stemmed from reductions in surgical site events such as surgical site infections, seromas, and hematomas. Avoiding large laparotomy incisions mitigates risks of wound contamination and fluid collection. However, two nationwide database studies in the United States found higher complication rates with laparoscopic repair.[30,31] This discrepancy may relate to the learning curve required to gain proficiency with complex minimally invasive techniques.

Reassuringly, the odds of mesh infections were similar between open and laparoscopic approaches. Intraperitoneal mesh placement with laparoscopic IPOM raised theoretical infection concerns, but clinical studies have not borne out increased mesh infections compared to open repair.[32] With proper sterile technique and antibiotic prophylaxis, mesh infection risks are minimal with either approach.

The comparable rates of postoperative ileus and bowel obstruction between groups should also help assuage concerns regarding intraperitoneal adhesiogenic mesh placement with laparoscopic repair. While animal studies raised flags, clinical data has not demonstrated an increased obstruction risk.[33,34] Careful technique avoiding bowel trauma may mitigate adhesion formation during laparoscopic ventral hernia repair.

Time to return to normal activities was reported in only a few included studies, precluding pooled analysis. Available data does consistently demonstrate faster recovery and return to work with laparoscopic repair.[14,15] This significant functional benefit impacts patients' quality of life after hernia surgery.

Recurrence rates were seldom reported in the early follow-up periods examined here. Longer term data has shown laparoscopic and open approaches yield similar recurrence rates.[35] Mesh fixation methods may play a role, with some studies suggesting permanent tacks increase durability compared to absorbable tacks or transfascioal sutures.[36]

Limitations

Limitations of this analysis include the inherent heterogeneity among included studies. Surgical details including mesh types, fixation methods, defect

characteristics, and concomitant procedures varied. Combining RCTs with observational data also has limitations, but sensitivity analyses supports the robustness of the findings. Additional RCTs would further strengthen the evidence. Publication bias remains a possibility, but was not detected on funnel plot symmetry and Egger's testing.

CONCLUSION

This meta-analysis supports the use of the laparoscopic approach for ventral/incisional hernia repair. Compared to open repair, laparoscopic IPOM results in shorter hospital stays, less pain, faster recovery, and fewer wound complications postoperatively. The risks of mesh infection and bowel obstruction are comparable between techniques. Increased operative duration with laparoscopic repair highlights the importance of structured training to ascend the learning curve. Further studies evaluating impact on chronic pain and long-term recurrences will help refine best practices for laparoscopic ventral and incisional hernia repair.

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