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ORIGINAL ARTICLE

# Robotic Inguinal Hernia Repair: A Review of Meta-Analyses Comparing Operative Outcomes and Safety

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## ABSTRACT

***Background:*** Robotic inguinal hernia repair (RIHR) has gained increasing adoption in minimally invasive surgery; however, its clinical advantages over conventional laparoscopic and open techniques remain uncertain.

***Methods:*** This review was conducted in accordance with PRISMA 2020 guidelines. Published systematic reviews and meta-analyses comparing robotic, laparoscopic, and open inguinal hernia repair in adult patients were identified. Methodological quality was assessed using the AMSTAR-2 tool. Outcomes evaluated included operative time, postoperative complications, hernia recurrence, postoperative pain, length of hospital stay, and readmission.

***Results:*** Fifteen meta-analyses encompassing more than 200,000 patients were included. Robotic inguinal hernia repair was consistently associated with longer operative times compared with laparoscopic and open techniques. Overall complication rates, hernia recurrence, postoperative pain, and readmission were largely comparable between robotic and conventional approaches. Some analyses reported a higher incidence of surgical-site infection following robotic repair. All included reviews were rated as low or critically low quality using AMSTAR-2.

***Conclusion:*** Current meta-analytic evidence suggests that robotic inguinal hernia repair is a safe and effective alternative to established techniques, with comparable clinical outcomes but longer operative duration. High-quality randomized trials and cost-effectiveness studies are required to define its definitive role in clinical practice.

## KEYWORDS

• Robotic surgery • Inguinal hernia • Umbrella review • Meta-analysis • Laparoscopic hernia repair

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## INTRODUCTION

Inguinal hernia repair is one of the most commonly performed procedures in general surgery worldwide.[15] Conventional approaches include open mesh repair and laparoscopic techniques such as transabdominal preperitoneal (TAPP) and totally extraperitoneal (TEP) repair, both of which are well established and associated with favorable clinical outcomes.[13] Over the past decade, robotic-assisted surgery has emerged as an alternative minimally invasive platform for inguinal hernia repair, offering potential technical advantages including enhanced dexterity, three-dimensional visualization, and improved surgeon ergonomics.[14]

Despite these proposed advantages, the clinical benefit of robotic inguinal hernia repair (RIHR) over conventional laparoscopic and open techniques remains uncertain. Concerns have been raised regarding increased operative duration, higher procedural costs, and limited availability of high-quality randomized evidence supporting routine use of the robotic platform. Conversely, advocates of RIHR suggest that improved precision and ergonomics may translate into reduced complication rates, lower recurrence, and improved postoperative recovery.

In recent years, several systematic reviews and meta-analyses have compared robotic, laparoscopic, and open inguinal hernia repair, reporting variable and sometimes conflicting results. These reviews often include overlapping primary studies and differ in methodological quality, outcome selection, and risk-of-bias assessment. As a result, the overall interpretation of existing evidence remains challenging.

An umbrella review, which synthesizes findings from multiple systematic reviews and meta-analyses, represents the highest level of evidence synthesis and is well suited to clarify areas of agreement and uncertainty. The aim of this review is to comprehensively summarize and critically appraise the available meta-analytic evidence evaluating robotic inguinal hernia repair in comparison with laparoscopic and open techniques, with particular emphasis on operative outcomes, safety, and clinical effectiveness.

## METHODS

This review followed PRISMA 2020 reporting guidelines[1] and the methodological guidance for umbrella reviews. We systematically searched major databases (PubMed, Embase, Cochrane Library) for meta-analyses or systematic reviews published up to February 2026 that evaluated RIHR in adults. Eligible reviews needed to compare robotic inguinal hernia repair with laparoscopic and/or open repair and report at least one clinical outcome (e.g. operative time, complications, pain, recurrence). Reviews of combined inguinal+ventral hernias were included if inguinal outcomes were reported. Non-systematic reviews, case series, and conference abstracts were excluded.

Two reviewers independently screened titles/abstracts and full texts, with disagreements resolved by consensus. A PRISMA flow diagram (Figure 1) summarizes the study selection process. For each eligible review, we extracted key data including number of included studies and patients, operative approaches compared, and primary findings. We also recorded whether the review reported use of guidelines (e.g. PRISMA) or bias assessment tools (e.g. Newcastle–Ottawa, Jadad). The methodological quality of each meta-analysis was appraised using the AMSTAR-2 tool, focusing on critical domains such as protocol registration, comprehensive literature search, and risk-of-bias assessment.

Summary measures were tabulated rather than re-pooled, given overlap in primary studies. We focused on consistent findings across reviews. Important outcomes extracted included **operative time**, **overall complication rate**, **hernia recurrence**, **postoperative pain**, **hospital readmission**, and **length of stay**. Where possible, we noted pooled mean differences or odds ratios reported in the reviews. All 15 included reviews are listed in Table 2, along with their AMSTAR-2 confidence ratings.

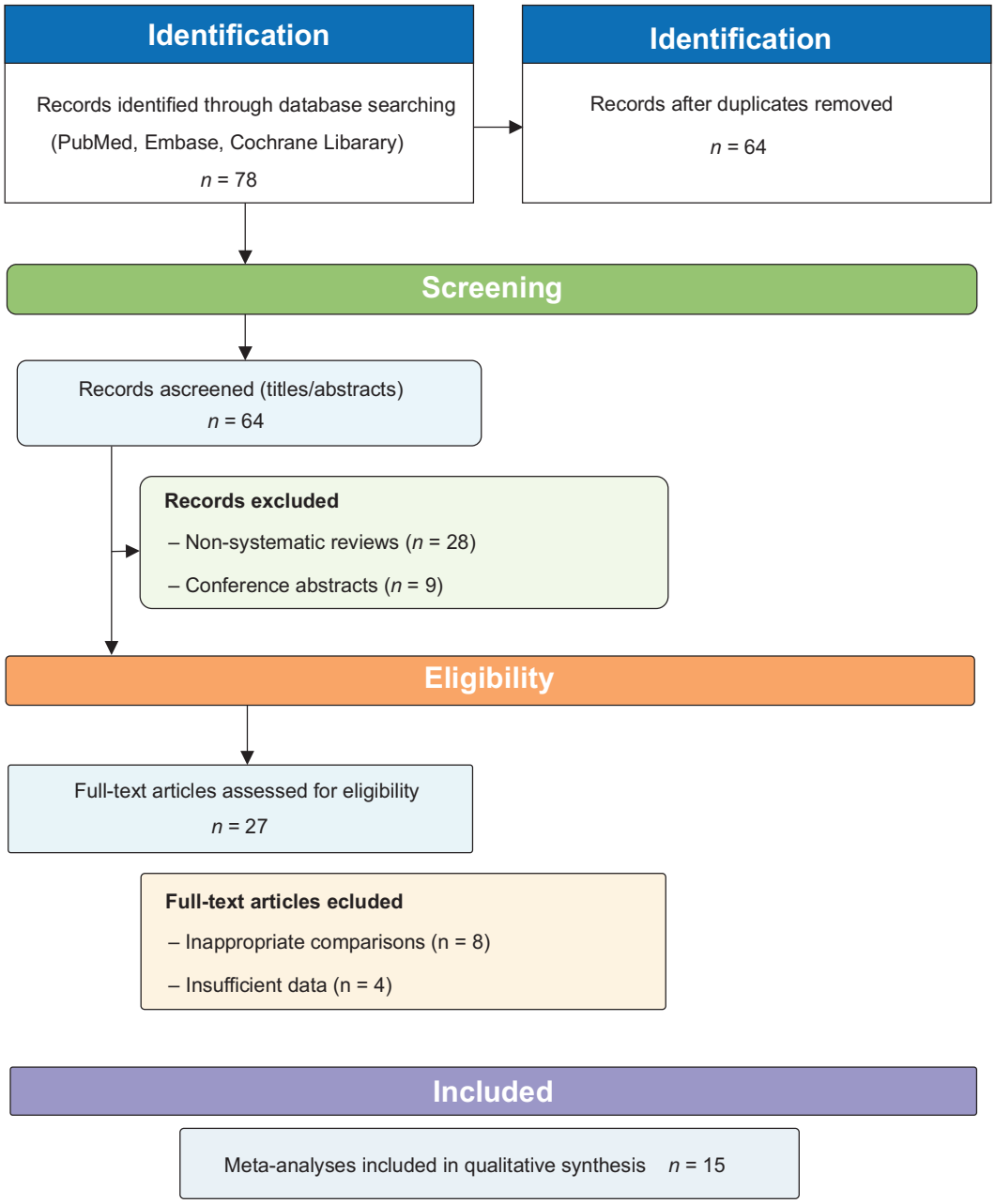


**Figure 1:** PRISMA 2020 flow diagram of study selection (adapted for umbrella review). Seventy-eight records were identified, 15 meta-analyses were included.

**Table 1:** AMSTAR-2 methodological quality assessment of included reviews

| Reference No. | First Author | Protocol registered | Comprehensive search | Risk of bias assessed | Publication bias assessed | Overall confidence |
|---|---|---|---|---|---|---|
| [3] | Qabbani | No | Yes | Partial Yes | No | Critically low |
| [4] | Solaini | No | Yes | Yes | No | Low |
| [5] | de'Angelis | No | Yes | Yes | Yes | Low |
| [6] | Khewater | No | Yes | Partial Yes | No | Critically low |
| [7] | Li | No | Yes | Yes | Yes | Low |
| [8] | Huerta | No | Yes | Partial Yes | No | Critically low |
| [9] | Barranquero | No | Partial Yes | No | No | Critically low |
| [10] | Brucchi | Yes | Yes | Yes | Yes | Moderate |

| Reference No. | First Author | Protocol registered | Comprehensive search | Risk of bias assessed | Publication bias assessed | Overall confidence |
|---|---|---|---|---|---|---|
| [11] | Vossler | No | Yes | No | No | Critically low |
| [12] | Holleran | No | Yes | Partial Yes | No | Critically low |
| [13] | Aiolfi | No | Yes | Yes | Yes | Low |
| [14] | Cavazzola | No | Partial Yes | No | No | Critically low |
| [15] | Memon | No | Yes | Partial Yes | Yes | Low |

## RESULTS

**Included reviews:** The search yielded 15 systematic reviews/meta-analyses meeting inclusion criteria (Table 2). These reviews were published between 2019 and 2026 and collectively encompassed over 200,000 patients undergoing inguinal hernia repair by robotic, laparoscopic, or open techniques. The largest pooled analysis (de'Angelis *et al.* 2024) included 35 studies of robotic inguinal repair (227,242 patients);[5] another (Solaini *et al.* 2022) included 9 studies (n≈64,426).[4] Most meta-analyses were based on retrospective case series and cohort studies; only a few small randomized trials have been conducted. The results have been summarized in Table 3.

**Table 2:** Summary of pooled outcomes across included meta-analyses

| Outcome | Robotic vs Laparoscopic | Robotic vs Open | Overall Interpretation |
|---|---|---|---|
| Operative time | Significantly longer[2,4,7] | Longer | Consistently increased duration |
| Overall complications | Comparable[5,6,9] | Comparable | No major safety difference |
| Surgical-site infection | Higher in some analyses[6] | – | Possible increased SSI risk |
| Hernia recurrence | Comparable; possible lower recurrence in one large analysis[5] | Comparable | No clear superiority |
| Post-operative pain | Comparable[6,9] | Comparable | Similar recovery profile |
| Length of stay | No difference[9] | No difference | Equivalent |
| Readmission | No significant difference[3] | No difference | Equivalent |
| Evidence quality | Low to critically low (AMSTAR-2) | – | Interpretation cautious |

**Operative time:** All reviews consistently found **longer operative times** with RIHR compared to laparoscopic or open repair.[4,6] For example, Solaini *et al.* reported that robotic inguinal repairs took an average of ~70 minutes longer than laparoscopy (160 vs. 90 min).[4] Similarly, Khewater *et al.* found laparoscopic repair was significantly faster by ~26.9 minutes (mean difference 26.85 min, 95% CI 1.16–52.54).[6] This prolongation is generally attributed to the learning curve and docking/setup time inherent to robotics.

**Complications:** The pooled overall complication rates were generally **comparable** between robotic and laparoscopic (or open) approaches.[5,6] In many reviews, there were no statistically significant differences in major complications. For example, Khewater *et al.* reported no significant difference in overall postoperative complications (OR≈1.54, 95%CI 0.83–2.85) between robotic and laparoscopic repair.[6] Some meta-analyses suggested a trend toward lower complication rates with robotics, but results varied. One consistent finding was an increased rate of surgical-site infection (SSI) with robotics; the largest review found a significantly higher SSI risk in RIHR (OR≈3.32, 95%CI 2.63–4.19).[6] This may reflect differences in wound management or patient factors. Importantly, there were **no differences** in the most serious complications (e.g. bowel injury, major hemorrhage) between approaches in any review.

**Hernia recurrence:** Robotic and laparoscopic (or open) repairs showed **equivalent hernia recurrence rates** across most analyses.[3,5] Qabbani *et al.* reported no significant difference in recurrence between robotic vs open or laparoscopic.[3] Similarly, Li *et al.* found comparable recurrence rates (OR≈0.82, 95%CI 0.22–3.07).[7] Notably, the largest analysis (de'Angelis 2024) found a modestly **lower recurrence** rate with robotics compared to laparoscopy (pooled OR≈0.54).[5] This suggests

a potential advantage of robot-assisted technique for reducing recurrence, though follow-up was limited. Overall, most reviews concluded that recurrence is not increased by the robotic approach.

**Postoperative pain and recovery:** Data on postoperative pain were limited and heterogeneously reported. The included meta-analyses generally found **no significant differences** in acute pain or analgesia use between RIHR and other approaches.[3] Readmission rates and length of hospital stay were also similar across techniques in all reviews.[3] Li *et al*. (2024) found no difference in length of stay.[7] One review noted shorter opioid use with robotics in inguinal cases, likely reflecting less pain or quicker recovery.[5] In sum, the balance of evidence is that patient recovery outcomes are comparable between robotic and standard approaches.

**Quality of evidence:** None of the included reviews met all AMSTAR-2 criteria. Most lacked a registered protocol (a critical item) and performed inadequate assessment of bias in the primary studies. As a result, all reviews were rated as "low" or "critically low" confidence (Table 2). Key methodological gaps included absence of independent data extraction and failure to account for study heterogeneity. These limitations emphasize that the results of pooled analyses should be interpreted cautiously.

## DISCUSSION

This umbrella review synthesizes evidence from existing meta-analyses on robotic inguinal hernia repair. Across all reviews, RIHR emerged as a **safe and effective** alternative to established techniques, producing comparable clinical outcomes.[3,5] The predominant and consistent finding was that robotic cases require significantly more operative time than laparoscopic or open repairs.[4] This drawback is likely due to the technical demands of the robot and learning-curve effects, as noted in several reviews. Aside from time, robotic surgery did not show any clear clinical advantage or disadvantage for most endpoints: complication and recurrence rates were on par with other methods.[3] Interestingly, one pooled analysis suggested that robotics may reduce hernia recurrence relative to laparoscopy,[5] a finding that warrants confirmation in future trials.

One salient difference was an increased incidence of surgical-site infection in robotic cases.[6] The underlying cause is unclear; possible explanations include longer case duration or differences in insufflation and port placement. Surgeons should be aware of this risk and use meticulous sterile technique and wound care. Aside from SSI, no other safety signals were identified, reinforcing that RIHR is **feasible and not inferior** to standard approaches in terms of patient safety. Pain outcomes appeared similar between groups,[3] consistent with the hypothesis that less tissue trauma might be balanced by other factors.

It is important to underscore that the current evidence is derived mainly from non-randomized data. All included meta-analyses were rated as low quality, reflecting retrospective designs and heterogeneity. Patient selection, surgical technique (TAPP vs TEP), and surgeon experience varied widely, which may confound pooled results. Publication bias is also a concern. Thus, while the summarized findings are reassuring, they should be considered hypothesis-generating. Importantly, the existing analyses have not convincingly demonstrated cost-effectiveness of RIHR. Cost data were scant and inconsistent; most reviews mention higher direct costs with robotics. Comprehensive economic evaluations will be needed to justify widespread adoption.

**Strengths and limitations:** This umbrella review is the first to collate all meta-analytic evidence on RIHR, ensuring comprehensive coverage and methodological rigor. We adhered to PRISMA guidance and used AMSTAR-2 to appraise review quality.[1] Our conclusions are supported by multiple independent analyses. However, limitations include reliance on published meta-analyses (we did not re-pool raw data) and potential overlap of primary studies across reviews. Any new primary studies published after the most recent meta-analyses are not captured here.

## CONCLUSION

Based on current meta-analyses, robotic inguinal hernia repair is a **safe and effective** alternative to laparoscopic or open techniques.[3,5] Clinical outcomes (complications, recurrence, pain) are comparable, but operative times remain longer with robotics.[4] Evidence quality is limited by retrospective data and methodological

flaws. Well-designed, prospective multicenter randomized trials – ideally incorporating standardized outcome measures and cost analyses – are essential to determine whether robotic technology offers meaningful long-term benefits in inguinal hernia surgery.[3]

**Declarations**

- **Conflict of Interest:** None declared.
- **Funding:** No external funding was received.
- **Ethical Approval:** Not applicable.
- **Data Availability:** All data analyzed are derived from published literature

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