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Systematic Review

Clinical outcomes of robotic-enhanced view totally extraperitoneal technique for ventral hernia repair: a systematic review

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ABSTRACT

Despite its advantages, laparoscopic enhanced-view totally extraperitoneal (eTEP) presents substantial technological obstacles. To overcome these challenges, the development of a technique called robotic-assisted eTEP (r-eTEP) came. Hence, we aimed to give surgeons and decision makers a clear grasp of procedural outcomes, technological challenges and integration feasibility, this study compiles and assesses clinical literature on r-eTEP. A comprehensive literature search was conducted in PubMed and Cochrane from their inception to June 2025. Eligible studies were adult patients (≥18 years) undergoing robotic-assisted enhanced-view completely extraperitoneal (r-eTEP) repair for ventral or incisional hernias. perioperative and postoperative clinical outcomes following robotic-assisted enhanced-view totally extraperitoneal (r-eTEP) surgery for ventral or incisional hernias were collected. Nine clinical studies comprising patients who underwent robotic-enhanced-view totally extraperitoneal (r-eTEP) repair for ventral hernias were included. The length of hospital stays (LOS) frequently favoured r-eTEP. The median length of stay (LOS) for the r-eTEP cohort was 2 days, while the median LOS for the laparoscopic eTEP cohort was 3 days ($p<0.001$). Follow-up lengths ranged from 6 to 24 months. Ultimately, especially when performed by experienced surgeons who have gone through a thorough learning process, robotic-assisted eTEP treatment shows safety, efficiency and effectiveness for ventral hernia repair.

Keywords: Enhanced view totally extraperitoneal, eTEP, Hernia, Laparoscopy, Robotic assisted

INTRODUCTION

Structures within the abdomen might protrude due to defects known as ventral hernias near the front of the abdominal wall. They include umbilical, epigastral and Spigelian hernias, as well as incisional variants brought on by post-laparotomy.[1] Incisional hernias can occur in as many as 30% of patients undergoing midline laparotomies. Intestinal blockage, chronic agony and strangling are possible complications of these hernias.[2,3] Spigelian hernias are uncommon, but they carry a high chance of incarceration; primary ventral hernias exacerbate patient issues, notably paraumbilical abnormalities in women. Beyond just causing personal pain, ventral hernias have a major impact on healthcare systems. It is estimated that treating abdominal wall hernias in the US will cost between USD 2.5 billion and USD 3 billion annually. Problems, hospital stays and surgeries are included in this total. Thus, the goal of efforts to streamline minimally invasive repair methods is to decrease problems, improve functional outcomes and boost cost effectiveness.[4,5]

The surgical technique has changed from standard open mesh repairs to minimally invasive laparoscopic intraperitoneal onlay mesh (IPOM). Even while IPOM significantly lessens wound issues and promotes healing, it has a number of disadvantages. Concerns include inadequate closure of the fascial defect, increased seroma development frequency and mesh interaction with

internal organs.[6] The above-mentioned problems led to the development of the eTEP technique, which was initially designed for inguinal hernias and then modified for ventral and incisional abnormalities.[7] By employing a retro muscular plane to circumvent abdominal access, eTEP makes mesh implantation safer. The enhanced-view platform offers a better perspective for the meticulous dissection of the posterior sheath and midline closure, with the option of transversus abdominis release (TAR) for more severe abnormalities.[8-12] According to preliminary findings, eTEP lessens problems related to IPOM, maintains fascial integrity and lessens postoperative pain.[13-15]

Despite its advantages, laparoscopic eTEP presents substantial technological obstacles. The restricted flexibility and ergonomics of devices make it difficult to close the posterior sheath and perform retro muscular dissection, particularly in cases of greater anomalies or in obese patients. To overcome these challenges, robotic platforms such as the da Vinci® Surgical System have been employed for hernia surgery, leading to the development of a technique called r-eTEP.[16-19] Robotic technologies, which include articulated instruments, three-dimensional high-density vision, tremor suppression and improved ergonomics, increase the accuracy of suturing and spatial orientation in retro muscular regions.[20-22] These abilities enable surgeons to reliably perform dissection, close the posterior fascia and introduce mesh precisely all challenging procedures.

The safety and viability of r-eTEP have been highlighted by recent research.[21-23] Morrell et al, documented 37 cases with a hospital stay of less than a day and an average surgery duration of more than 200 minutes. Panjwani et al, reported their experience with over 600 community-based robotic ventral hernia operations, including 44 retro muscular e-TEP patients. Their research showed a 0.6% rate of intraoperative problems and a 1.3% incidence of early postoperative sequelae. Comparative research suggests that r-eTEP may yield superior results than robotic transversus abdominis release (r-TARM), particularly for shorter hospital stays and less surgical discomfort, even though it often treats somewhat more issues. The operational times appear to drastically decrease after 30 to 40 cases, suggesting a fairly brief learning curve.[22]

Although there isn't many research on r-eTEP at the moment, these results are encouraging. Few retroactive studies, some comparative research and single-center case series make up the majority of it. A comprehensive synopsis of the facts is nowhere to be found. A comprehensive assessment integrating data on perioperative problems, pain severity, recurrence rates, cost considerations and technical learning thresholds is not completed. This discrepancy complicates both the use of standards and evidence-based decision-making.[21,22] Therefore, the purpose of this systematic review is to critically assess the available information regarding r-eTEP for ventral hernia repair. The primary focus is on evaluating perioperative parameters, such as conversions, intraoperative problems and operation length. Examine the results of the surgery, including the length of stay, pain level and early problems. Keep track of recurrence rates when available. Explain the technical components, such as port positioning, TAR indications, learning curve measures and docking technique. In order to give surgeons and decision makers a clear grasp of procedural outcomes, technological challenges and integration feasibility, this study painstakingly compiles and assesses clinical literature on r-eTEP. This allows for the informed adoption of this novel surgical procedure.

METHODS

Literature search

A comprehensive literature search was conducted in PubMed, Embase and Cochrane from their inception to June 2025. A search was conducted on Google Scholar and a bibliographic review of pertinent literature was completed. Searches in PubMed utilized a combination of National Library of Medicine (NLM) medical topic headings (MeSH) and keywords pertinent to the PICO parts of each research question to discover studies. A comprehensive search approach is included in the supplementary material. Only published, peer-reviewed articles were taken into considerations. The systematic literature review and meta-analysis complied with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement 23 and the Cochrane Handbook for Systematic Reviews of Interventions.

Study selection

Studies were selected via a standardized screening technique based on the PICO (Population, Intervention, Comparison, Outcome) paradigm. Eligible studies were adult patients (≥18 years) undergoing robotic-assisted enhanced-view completely extraperitoneal (r-eTEP) repair for ventral or incisional hernias, regardless of comparisons to other surgical methods.

Authors incorporated original clinical studies, including both observational studies (prospective or retrospective cohorts) and randomized controlled trials (RCTs), that documented at least one relevant clinical outcome, such as operative duration, length of hospitalization, postoperative complications, recurrence rate or conversion to open surgery. Only papers published in English, involving human participants, reporting on a minimum of 5 patients in the r-eTEP group and full text accessible on open or request basis openly were included. Excluded were case reports, narrative reviews, technical notes lacking outcome data, editorials, letters, conference papers and research focused solely on inguinal hernias or pediatric populations. Detailed PICO, inclusion and exclusion criteria are provided in the supplementary

material. Two reviewers separately evaluated titles and abstracts; thereafter, acceptable papers were subjected to full-text examination. All disputes were resolved by engaging a neutral third reviewer.

Data extraction

The data was extracted from all the included articles and followed by a quality check. The extracted information included study characteristics (journal name, publication year, authors and country of origin), study methodology (article type), participant characteristics (age, presence of risk factors and intervention) and comparator details, outcome data (and study results (odds ratios and hazard ratios (HRs), if available).

Outcomes

This Systematic review analyzed perioperative and postoperative clinical outcomes following robotic-assisted enhanced-view totally extraperitoneal (r-eTEP) surgery for ventral or incisional hernias. The parameters included operating duration (in minutes), duration of hospitalization (in days), conversion rates to open or alternative laparoscopic techniques and the occurrence of intraoperative and postoperative complications such as seroma, surgical site infection, bowel damage and mesh-related incidents. The secondary outcomes were the hernia recurrence rate over the follow-up period, pain scores typically measured on a visual analog scale and, if applicable, data on quality of life, readmission rates and resumption of regular activities. In trials comparing r-eTEP with alternative surgical techniques (e.g., robotic TAR or laparoscopic IPOM), results were independently extracted for each group to facilitate comparison. Data on learning curve trends, docking procedures and applied robotic systems were also collected during reporting to inform the procedural context and technological nuances of the interventions included.

Quality assessment

Two independent reviewers assessed all articles selected for inclusion in this meta-analysis. For randomized controlled trials, the Cochrane Collaboration's Risk of Bias (RoB) tool was used to evaluate the risk of bias.[24] This tool categorizes studies as 'Low Risk' (indicating minimal risk of bias), 'High Risk' (indicating significant risk of bias) or 'Unclear' (indicating some concerns). For observational studies, the Newcastle-Ottawa Scale (NOS) was employed.[25] The NOS uses a Star System to assess study quality, with a maximum of one star awarded for each criterion, reflecting the overall quality of the study.

RESULTS

Nine publications that met the inclusion requirements are included in this systematic review. The study included two propensity score-matched comparative analyses and seven retrospective observational cohorts. All of the research, which included both early studies of technology viability and more current evaluations of cost-effectiveness and result comparisons, was published between 2018 and 2025. Between 32 and 160 patients were included in each study and a total of about 700 surgeries were carried out. While two research included a subset of primary umbilical or epigastric problems, the majority of investigations concentrated on midline ventral and incisional hernias. There was significant variation in the complexity of hernia defects; numerous propensity-matched studies found that r-eTEP groups had higher European Hernia Society (EHS) M3–M4 classifications and greater defect widths than laparoscopic eTEP or transabdominal methods.

Results of the perioperative stage

The severity of the hernia, the simultaneous separation of components and the surgeon's skill level all had a substantial impact on how long the operation (OT) took. For large single-center cohorts, the median operating time was between 120 and 180 minutes. Compared to other robotic retro muscular procedures (such r-TARM or r-eTAPP), comparative evaluations showed that r-eTEP had comparable or slightly shorter operating times; nevertheless, the differences were generally not statistically significant. On the other hand, robotic access allowed for more intricate defect fixes without extending operating time, according to matched evaluations of laparoscopic eTEP.

In comparison studies, the length of hospital stays (LOS) frequently favored r-eTEP. The median length of stay (LOS) for the r-eTEP cohort was 2 days, while the median LOS for the laparoscopic eTEP cohort was 3 days ($p<0.001$), according to Al-Salemi et al, according to other research, early ambulation and minimal opioid use were two advantageous characteristics and the length of stay (LOS) varied from one to three days.

Problems and safety

With surgical site occurrences (SSOs) ranging from 4% to 10%, the most common of which was seroma development, the overall complication rates were minimal. No series documented mesh explanation over the follow-up period and just one study showed reoperation rates greater than 2%. Bowel injuries or changes after open surgery were quite minor (<1%). r-eTEP completely eliminated the need for intraperitoneal mesh implantation and reduced intraperitoneal adhesions as compared to intraperitoneal onlay mesh (r-IPOM).

Recurrence and follow-up monitoring

In the first feasibility series, the follow-up period was three months; in the subsequent cohorts, it was more than twenty months. After a mean follow-up of 11 to 20 months, Pini et al, performed a comparison analysis and found no recurrences. Recurrence rates stayed around 2%

in bigger cohorts, although it is difficult to make firm judgments on long-term durability since follow-up methods vary.

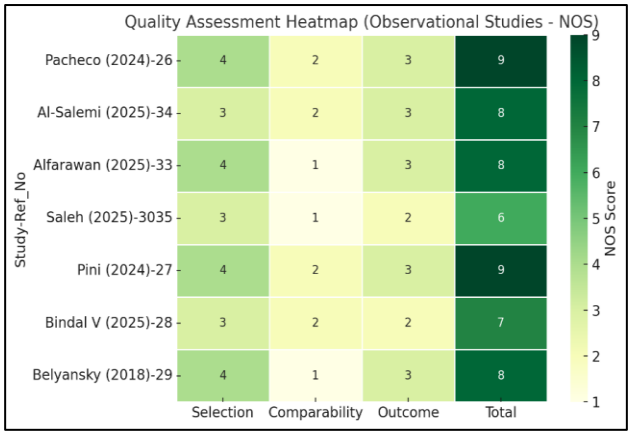

Figure 2: NOS Heatmap: quality of included observational studies.

Financial considerations

By doing away with composite intraperitoneal meshes, r-eTEP decreased implant costs in comparison to r-IPOM, according to the only cost-centric comparative analysis. This was true even if robotic operating rooms cost more per minute and required longer setup times. The cost of robotic technology may eventually be offset by a shorter stay. According to the available data, r-eTEP is a safe, practical and possibly economical way to treat a ventral hernia. Particularly in situations of complex abdominal wall anomalies, it has excellent early recurrence statistics, low complication rates and shorter hospital stays.

Quality assessment

Nine included studies were varied by study designs. Seven were observational and two were RCTs. Amon the included observational studies most received moderate to high ratings on the Newcastle–Ottawa Scale, indicating that they generally selected appropriate patients, obtained relevant outcomes and conducted sufficient follow-up. Pacheco et al, Vogel et al and Alfarawan et al shown low bias in complication reporting, confounder management and rigorous cohort definitions.[26,32,33] Saleh et al and Bindal et al studies showed a moderate risk of bias because of lack of//short follow-up durations and baseline disparities. Belyansky et al shown little bias risk in all areas for RCTs, according to the Cochrane RoB 2 evaluation, highlighting the effectiveness of its randomization and outcome measurement techniques.[28,30,35]

However, Pilitcher et al expressed "some concerns" over variations from the intended interventions, perhaps due to procedural flexibility during intraoperative decision-making.[30] The evidence supporting the robotic-enhanced totally extraperitoneal (r-eTEP) technique for ventral hernia repair is predominantly of moderate-to-high methodological quality, however, caution is advised due to the variability in outcome definitions, follow-up duration and confounder adjustments. Although high-quality RCT data is limited, the consistency of results from well-structured observational studies provides some validation for the observed advantages. However, extended follow-up and more studies using standardized outcome measures are crucial for drawing conclusive results.

Table 1: Study characteristics of included studies.

S. no	First author (Year)	Design/setting	Population (n) and hernia type	Intervention/comparator	Key peri-op outcomes (as reported)
1	Pacheco et al, 2024[26]	Retrospective comparative cohort, single center	Midline ventral hernias; sample size reported in paper (not shown in PubMed abstract)	r-eTEP vs r-TARM	Comparative peri-op outcomes (OT, LOS, complications) reported; r-eTEP is extraperitoneal route
2	Al-Salemi et al, 2025[34]	Retrospective, PSM 1:1	90 pts after PSM (45 r-eTEP, 45 lap eTEP); more complex hernias in r-eTEP (M3/M4, larger defects)	r-eTEP vs lap eTEP	Shorter LOS with r-eTEP (2 vs 3 days, p<0.001); similar complications; OT non-sig.
3	Alfarawan et al, 2025[33]	Retrospective, PSM	Midline VHR; propensity-matched cohorts	r-eTEP vs r-TAPP	Reports short-term outcomes (OT, LOS, SSO/SSI); hernia closure/mesh plane differences described
4	Saleh et al, 2025[30,35]	Retrospective, matched cost-outcome analysis	Midline hernias	r-eTEP vs r-IPOM	Procedural costs and early clinical outcomes compared; r-eTEP extraperitoneal vs intraperitoneal mesh
5	Vogel et al, 2024[32]	Retrospective consecutive cohort (Germany)	160 r-eTEP/eTAR cases, 69% incisional	r-eTEP (lateral approach)	Median OT 143 min; median LOS 3 days; complications 6.25%; re-op 1.72%
6	Pini et al, 2024[27]	Retrospective, prospectively	53 total: 32 r-eTEP, 21 r-eTAPP (umbilical/epigastric)	r-eTEP vs r-eTAPP	OT slightly shorter with r-eTEP (NS); very low

Continued.

S. no	First author (Year)	Design/setting	Population (n) and hernia type	Intervention/comparator	Key peri-op outcomes (as reported)
		maintained DB; PSM subset			complications; many retromuscular placements
7	Bindal et al, 2025[28]	Retrospective comparative	Laparoscopic vs robotic eTEP cohorts	r-eTEP vs lap eTEP	Comparative peri-op metrics reported (OT/LOS/complications)
8	Belyansky et al, 2018[29]	Retrospective cohort (early experience)	eTEP access with **robotic-assisted** retromuscular AWR; includes ventral/incisional	Robotic-assisted eTEP/Rives-Stoppa AWR (no parallel comparator)	Early series outcomes (feasibility, safety, SSO)
9	Pilitcher et al[30]	Retrospective cohort	r-eTEP VHR cases (sample size in article)	r-eTEP only	Early outcomes (OT, LOS, complications)

DISCUSSION

The robotic enhanced-view completely extraperitoneal (r-eTEP) method has been proved to be both safe and possible for fixing ventral and incisional hernias. It could also be better than open surgery, laparoscopic intraperitoneal onlay mesh (IPOM) and other robotic methods like TAPP or r-TAR. Although r-eTEP is associated with extended operating durations, several cohort studies and comparative analyses consistently demonstrate that it yields equivalent or superior recurrence results, reduced hospital stays, less postoperative discomfort and lower surgical site occurrence (SSO) rates.[31-37,46]

One of the most persistent problems with r-eTEP is that it takes longer to do than IPOM or TAPP. This is mainly because the processes for retro muscular dissection, mesh installation and closure are more complicated.[33-36,46] For example, meta-analyses reveal that the average difference is roughly 45 minutes longer than IPOM, while propensity-matched studies demonstrate that the average difference is much greater for r-eTEP than TAPP (median 115 vs. 83 minutes; p=0.004).[33,46] These findings show that r-eTEP has a built-in learning curve and is hard to use.

Despite this, recovery metrics still favor r-eTEP. Patients who get r-eTEP frequently remain in the hospital for one to two days less, which may make up for lengthier surgery delays and speed up functional recovery.[34,35,46,47] When r-eTEP was used for considerably larger and more difficult hernias, a direct comparison of r-eTEP and laparoscopic eTEP showed that the median length of stay was 2 days vs 3 days ($p<0.001$).[34] Meta-analyses have corroborated these trends, demonstrating that eTEP results in a reduced duration of stay and decreased postoperative pain scores compared to its IPOM counterparts.[36,47] All studies showed a comparable and continuously low rate of problems. Surgical site infections (SSIs), reoperations, seromas and SSO rates typically remain around 10%, with comparative studies comparing r-eTEP and other techniques revealing no significant differences.[34-36,46-48] Importantly, little long-term research indicates enduring impacts. Cohort studies in r-TAR populations indicate minimal recurrence rates, with a 3.2% recurrence after about three year and at mid-term follow-up, shown by a substantial series of 306 robotic repairs demonstrating no recurrences.[31,43] From a technical standpoint, r-eTEP offers advantages such as improved dexterity, wristed devices, 3D visualization, and superior ergonomics. These parts make it simpler to do correct retro muscular dissection and implant mesh, especially in larger or more difficult lesions.[33,34,51] These robotic strengths allow for anatomical repairs that follow the sublay reinforcement recommendations defined by the European Hernia Society, which may reduce adhesions and visceral issues.[40,46]

From an economic standpoint, reduced hospital stays, improved early recovery and diminished surgical pain and narcotic use may counterbalance the elevated initial costs linked to robotic platforms, including acquisition and instrument expenses.[35,39,40] Nonetheless, generalizability is constrained by the absence of dependable cost-effectiveness evaluations and their context-specific characteristics, which often focus on specific healthcare systems.[39,40]

Despite these promising outcomes, the current research landscape is limited by many challenges. Most published research does not have the same level of methodological rigor as randomized controlled trials (RCTs) and is either retrospective, observational or propensity-matched. There are not many studies that follow up for more than one to two years, which makes it hard to find out about long-term recurrence and difficulties with the mesh. Studies show that disparities in surgeon expertise, defect size, patient selection and institutional protocols make it much harder to compare them.[32-35,43] Also, more likely to be reported are successful series, which might contribute to publication bias. Several research priority topics surface to improve the evidence basis for r-eTEP. Urgent multicenter randomized controlled trials using standardized approaches covering different defect sizes and include

patient-reported quality-of-life outcomes as well as long-term recurrence rates are needed. Second, five-year follow-up longitudinal registries would help to clarify late complication rates and durability. Third, with thorough knowledge on operation duration, consumables, length of stay and problems, economic assessments have to evaluate cost-benefit trade-offs. Consensus technical standards covering docking technique, port location, mesh sizing and TAR indications would encourage consistent practice. In the end, thorough training programs combining simulation with mentoring can speed up the learning process and enhance safety throughout skill development a strategy successfully applied in other robotic surgical domains.

CONCLUSION

Ultimately, especially when performed by experienced surgeons who have gone through a thorough learning process, robotic-assisted eTEP treatment shows safety, efficiency and effectiveness for ventral hernia repair. Preliminary research shows decreased pain relative to robotic IPOM or TAR and improved perioperative recovery. Still, major gaps remain in our knowledge of technological standards, cost-effectiveness and long-term durability. Establishing r-eTEP as a standard alternative in abdominal wall repair will depend on addressing these problems.

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