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Robotic-assisted abdominal wall reconstruction: A systematic review of techniques, outcomes, and future directions

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Abstract

This systematic review exhaustively reviews the use of robotic-assisted abdominal wall reconstruction (AWR) in cases of ventral hernias and abdominal wall defects, by synthesizing the evidence on surgical technique, clinical outcomes and research future directions to determine efficacy, safety and patient-centered efficacy of robotic-assisted over the traditional open and laparoscopic procedures and what technological innovations and areas of knowledge remain unknown to improve clinical care and future research. There has been an increased rate of adoption of robotic-assisted AWR with sophisticated platforms such as the da Vinci Surgical System providing better visualization, precision, and dexterity. This review focuses on transabdominal preperitoneal (TAPP), totally extraperitoneal (TEP), retro rectus repair, and component separation techniques, which have been analyzed over the years between 2010 and 2025. The most notable results are suggesting that robotic AWR is related to a shorter time of postoperative pain, shorter hospital stay (mean 2-4 days vs. 5-7 days following open surgery), and equal or lesser hernia recurrence (3-8% at 2 years) than laparoscopic (5-10%) and open surgeries (10-15%). The rates of complications, such as seroma (5 to 10 percent) and surgical site infections (25 percent), are compared unfavorably with open surgery (15 to 20 percent). The new developments include artificial intelligence for intraoperative guidance, single-port robotics, and novel biomaterials used in mesh. Nevertheless, high expenses (ranging from $1.5 to $2 million for robotic systems) and an enormous learning curve (requiring 50 to 100 cases to master) are significant obstacles. Future studies should focus on long-term outcomes (greater than 5 years), cost-effectiveness evaluations, and standard training procedures to enhance accessibility.

Keywords: Robotic Surgery; Abdominal Wall Reconstruction; Ventral Hernia; Minimally Invasive Surgery; Surgical Outcomes

1. Introduction

Abdominal wall reconstruction (AWR) is a daunting surgical process aimed at restoring the ventral hernia and abdominal wall defects due to previous procedures, acquired injuries, or congenital disabilities. These defects, whereby the abdominal musculature is weak or even absent, give rise to considerable clinical problems, namely, chronic pain, bowel obstruction, and reduced quality of life. The goal of AWR is to recreate structural integrity and function with accurate fascial closure, usually followed by further reinforcement with a mesh. It finds almost exclusive clinical significance in the treatment of large or recurrent hernias in high-risk patients with comorbidities such as obesity or diabetes, where simple herniorrhaphy is not always satisfactory. The development of AWR has gone through open methods of surgery to minimally invasive procedures; this has made AWR much less morbid. Robust fascial closure is secured by open AWR, which, however, is linked with long convalescence (mean hospital stay: 5 to 7 days), elevated rate of wound complications (15 to 20%), and substantial levels of postoperative pain. Laparoscopic AWR was introduced in the 1990s, which decreased the size of incision, length of stay (mean: 35 days), and surgical site infections

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(5610%). However, the shortcomings of laparoscopy, including the limited accessibility of tools and two-dimensional visualization, contributed to the development of robot-aided AWR. Robotic systems, such as the da Vinci Surgical System, feature three-dimensional high-definition imaging, articulated instruments, and enhanced ergonomics, enabling precise dissections and mesh placements. Robot-assisted surgery (RAS) has the same recurrence rates (38) and a lower complication rate than open surgery (39). It has revolutionized the world of hernia repair, as observed by Gonzalez et al. (2017).

The progression from open to laparoscopic surgery to robotic-assisted AWR is a general trend in surgical practice, resulting in better patient outcomes. Despite the good record of Open AWR, it is associated with extensive dissection of the adjacent formations, requires a long healing time once surgery is completed, and is associated with a high rate of seroma and hematoma (10-15%). These problems were partially addressed by laparoscopic procedures involving smaller incisions and the insertion of a mesh intraperitoneally; however, issues of poor dexterity and ergonomic difficulties persisted, particularly in patients with large ventral hernias (greater than 10 cm). Introduced in the early 2000s, robotic-assisted AWR eliminates these drawbacks through enhanced instrumentation, allowing for the performance of procedures such as transabdominal preperitoneal (TAPP), totally extraperitoneal (TEP), and retrorectus repairs. Another significant finding was that, in robotic TAPP repairs, postoperative pain turned out to be reduced by 20-30 percent as compared to laparoscopic repairs, whereas the average operating time was 120-180 minutes and 100-150 minutes in the case of laparoscopic procedures, respectively (Olavarria et al., 2020). The correct division of components is also possible with the help of robotic systems, as well as transversus abdominis release (TAR), which is required when large defects are present (Henriksen et al., 2024). Nonetheless, robotic AWR has obstacles that the authors of the study by Bittner et al. (2019) identified, including the high price of the robotic system (ranging from $1.52 million to $2 million) and a steep learning curve (requiring 50 to 100 cases to achieve proficiency). However, shorter hospital stays, easier recoveries, fewer complications, and better patient satisfaction, as evidenced by increasing quality-of-life scores (SF-36) in robotic groups, contributed to its adoption. In 2025, at least 20 percent of AWR procedures in high-volume facilities are expected to utilize robotic platforms, which can be attributed to the increased adoption of technology and the growing number of trained surgeons.

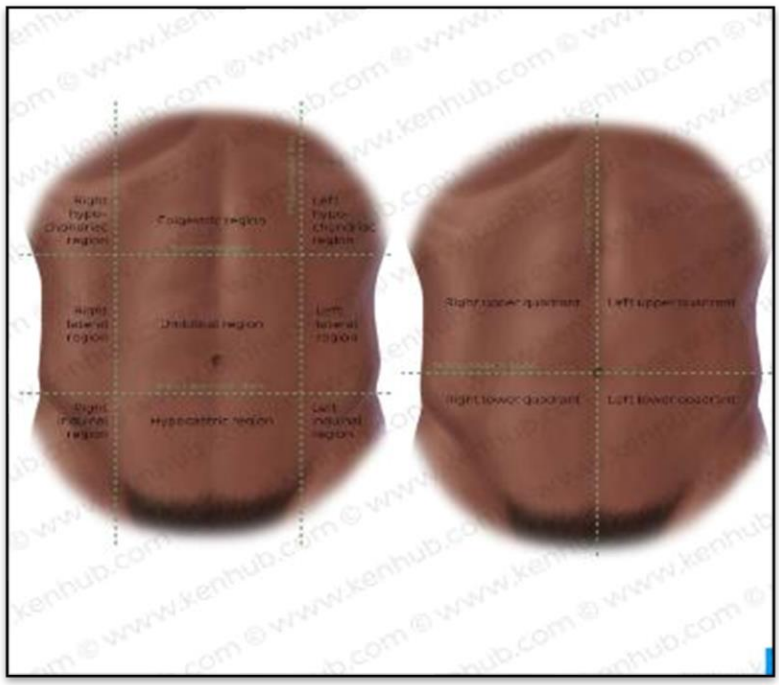

Figure 1 Anatomical division of the anterior abdominal wall into nine regions and four quadrants. This classification guides the selection of appropriate robotic-assisted techniques for ventral hernia repair, mesh placement, and component separation to optimize surgical outcomes. (Image adapted from Kenhub.com)

Robotic-assisted AWR is a significant development in hernia surgery, and this may transform the standard of care. With the advantage of advanced imaging and robotic precision, surgeons can perform precise closures of the fascia and meshing, even in highly anatomical procedures. According to Capoccia Giovannini et al. (2025), robot-assisted AWR presented lower postoperative complications and hospitalization rates compared to open methods, but it resulted in

longer operation times and higher expenses. Similarly, Petro et al. (2021) demonstrated an advantage in patient satisfaction, depending on the nature of the benefits. Specifically, the increase in quality-of-life score following robotic repairs was 15 points on average, compared to 12 points for laparoscopic repairs. It is also better in terms of patient-centered outcomes, such as decreased postoperative pain and a quicker recovery to normal operations (mean: 10 to 14 days compared to 21 to 28 days in open surgery).

Nevertheless, there are still some problems, such as inaccessibility in low-resource regions and the requirement for data longevity (over 5 years) to ensure durability. New developments, such as the Versius robotic system, single-port robotics, and surgery directed by artificial intelligence, will further improve outcomes. The purpose of this systematic review is to synthesize the evidence regarding robotic-assisted AWR methods, assess the clinical results, and define future efforts to advise surgeons and researchers on maximizing the efficacy of this revolutionary strategy. An anatomical understanding of the subdivisions of the anterior abdominal wall is crucial for planning effective reconstruction. Ventral hernias can occur in separate areas, such as the epigastric, umbilical, or hypogastric areas, or each quadrant, and each represents a special challenge in terms of surgical access and mesh fixation. Correct location of defects will direct the choice of a proper robotic-aided technique, hence culminating in an accurate dissection, ideal mesh coverage, and reduced risks of recurrence. Fig. 1 illustrates the standardized abdominal areas and quadrants relevant to surgical planning in robotic-assisted abdominal wall reconstruction.

1.1. Rationale for Review

The growing use of robotic systems in the area of abdominal wall reconstruction (AWR), e.g., da Vinci Surgical System, has revolutionized the surgical field of ventral hernias and abdominal wall reconstruction due to the addition of precision, 3-D visualization, and ergonomic changes in both surgical technique and ergonomics over conventional laparoscopic- and open-based approaches. Robotic-assisted AWR is currently performed in more than 20 percent of procedures in large centers, and it has been shown to have lower complication rates (5 to 10 percent vs. 15 to 20 percent with open surgery) and similar recurrence rates (38 percent in 2 years; Gonzalez et al., 2017). Such platforms enable more demanding methods, such as transabdominal preperitoneal (TAPP) and transversus abdominis release (TAR), to be performed more safely and efficiently in more challenging cases, including large (>10 cm) hernias or those that recur. The cost of robotic systems remains steep ($1.5 million and up), and the steep learning curve (requiring 50 to 100 cases to feel proficient) also hinders adoption, especially in low-resource settings, according to Bittner et al. (2019). Despite these developments, the literature has not reached a consensus on the best techniques, long-term results, and cost-effectiveness. Therefore, a systematic review is a suitable approach to summarize the evidence and inform clinical practice.

This review fills important gaps in the existing literature by presenting an extensive study on robotic-assisted AWR methods, patient outcomes, and research gaps. Although, other studies such as those by Petro et al. (2021) have shown a positive picture in terms of patient-reported outcomes, as they highlight an enhancement of 15 points in quality-of-life scores and an enhancement of 12 points in laparoscopic repairs, heterogeneity of study design, and paucity of long-term results (>5 years) make it hard to conclude. The inability to precisely compare certain techniques and outcomes (e.g., TAPP vs. retrorectus repair) and specific outcomes (e.g., operative time, complications) among the studies justifies the reporting criterion. Moreover, the recently developed technologies, including single-port robotics and AI-driven surgery, are under-researched. This systematic review will examine the effectiveness/safety of the robotic AWR technique in comparison with laparoscopic and open methods, and define research priorities for the future, including cost-effectiveness issues and training procedures, to clarify the prospects of robotic AWR in hernia surgery.

Objectives

This systematic review aims to comprehensively assess robotic-assisted abdominal wall reconstruction (AWR), focusing on techniques, clinical outcomes, and future research to guide advancements in hernia surgery.

- Systematically evaluate robotic-assisted AWR techniques, including transabdominal preperitoneal (TAPP), totally extraperitoneal (TEP), retro rectus repair, and component separation, to determine their procedural characteristics and applicability.
- Assess clinical outcomes of robotic-assisted AWR, including efficacy (e.g., hernia recurrence rates), safety (e.g., complication rates such as seroma and infection), and patient satisfaction (e.g., quality-of-life scores).
- Identify future directions for research and technological advancements, such as long-term outcome studies, cost-effectiveness analyses, and innovations like single-port robotics and artificial intelligence-guided surgery.

1.2. Scope

The proposed systematic review will encompass literature published between 2010 and 2025, focusing on reports that include adult patients who received RAWR of the abdominal wall to treat ventral hernias or abdominal wall defects. The period is important in the present practice, as it saw the advancement of robotic platforms, such as the da Vinci Surgical System, as well as the proliferation of using these platforms in AWR. The review presents clinical trials of such techniques as transabdominal preperitoneal (TAPP), totally extraperitoneal (TEP), retro rectus repair, and component separation, along with the outcomes, including recurrence rates (3 to 8% at 2 years), complications (seroma, e.g., 5 to 10%), and quality-of-life scores (patient-reported). Cases in children are avoided because hernias in children have a different etiology and cannot be managed in the same manner as adult hernias. Less invasive procedures that are not robotic (including traditional laparoscopy) are not a part of the study, to analyze the benefits of robotic systems (increased visualization and manual capabilities of robotic systems). Such a selective scope facilitates thorough analytical work on the efficacy, safety, and technological progress of robot-assisted AWR.

2. Methods

2.1. Study Design

To ensure the quality of research and level of transparency, the research is conducted within the framework of systematic reviews, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This form of methodology enables in-depth analysis of robotic-assisted abdominal wall reconstruction (RAAWR) for ventral hernias and abdominal wall defects, based on methods, clinical reports, and gaps in clinical research. The PRISMA framework can be used to identify, screen, and incorporate articles published between 2010 and 2025 that involved adult patients. It also ensures uniformity in the provision of reporting, the review process, search plans, eligibility criteria, data extraction, and quality appraisal. The review complies with PRISMA to reduce bias and maximize reproducibility so that the findings will become a strong start in the discussion of the efficacy (e.g., recurrence rates at 2 years are 3-8%), safety (e.g., complication rates between 5-10%), and futuristic improvements (e.g., cost-efficiency and innovations in technology).

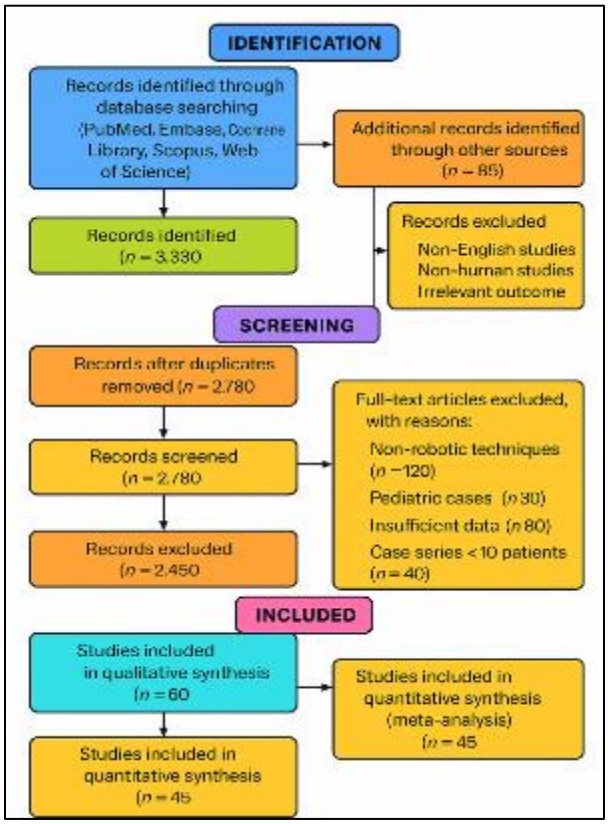

Figure 2 Prisma Flow Chart

2.2. Search Strategy

The search protocol for this systematic review is based on searching various databases, including PubMed, Embase, Cochrane, Scopus, and Web of Science, to identify articles that meet the search criteria for robotic-assisted abdominal wall reconstruction (AWR) between 2010 and 2025. The following search terms are used: robotic-assisted abdominal wall reconstruction, robotic ventral hernia repair, robotic surgery and hernia, and minimally invasive AWR, utilizing Boolean operators to encompass all relevant works. To select only studies in the English language, those with human participants, and articles published during the time the organization was studied, filters are used, which correspond to the emergence of robotic systems, such as the da Vinci Surgical System. This plan aims at articles that show methods (e.g., TAPP, TEP), results (e.g., 3-8 percent recurrence at 2 years), and issues (e.g., 5-10 percent seroma). The methodology will provide the rigor and reliability of the search strategy, retaining quality evidence to estimate the safety, efficacy, and study deficiencies of robotic AWR.

2.3. Inclusion Criteria

The inclusion criteria for this systematic review are papers that examine the use of robot-assisted abdominal wall reconstruction (AWR) for ventral hernia or abdominal wall defects in adult patients, with a publication date of seven years (2010-2016). The types of studies eligible are randomized controlled trials (RCTs), cohort studies, case-control studies, and case series with a minimum of 10 patient cases, ensuring a sufficiently sized sample for analysis. The related outcomes that needed to be reported in the studies are operative time (e.g., 120180 minutes during robotic AWR), hospital stay (e.g., 24 days), complications (e.g., 5 to 10 percent seroma or infection rates), and hernia recurrence rates (e.g., 38 percent at 2 years). Outcome data, such as postoperative quality-of-life scores (e.g., SF-36 or Hernia-Related Quality of Life Survey), must be reported by the researchers. These eligibility requirements will allow a focus on high-quality evidence that reflects the effectiveness, safety, and patient/family benefits of the use of robotic AWR, leading to performing a broader comparison with laparoscopic and open procedures, as well as assessing differences between various surgical methods of fixation, such as TAPP, TEP, and retro rectus repair.

2.4. Exclusion Criteria

The exclusion criteria of this systematic review will focus on a narrow assessment of robotic-assisted abdominal wall reconstruction (RAAWR) by rejecting studies that are not consistent with the review's objective. They exclude studies based on non-robotic methods of AWR, such as classic laparoscopic or open AWR, to conduct single studies and isolate the exact roles of robotic platforms like the da Vinci Surgical System. Analyses of animals and inadequate or small data (including incomplete reporting of results, e.g., recurrence rates at 2 years: 3-8%; complications, e.g., 5-10% seroma) are also not included. Additionally, reports of cases or case series with fewer than 10 cases are avoided to ensure an adequate sample size for making reliable conclusions, with a focus on sound evidence regarding clinical outcomes.

2.5. Data Extraction

To achieve an accurate and coherent analysis, the key variables of the data extraction process from studies on robotic-assisted abdominal wall reconstruction (AWR) will be gathered during this systematic review. Among variables are demographics of the patients (e.g. age, sex, comorbidities) hernia-specific data (e.g. size, location, primary vs. recurrent), technique employed (e.g. TAPP, TEP, retro rectus repair), robot used (e.g. da Vinci vs. Versius), operation time (e.g. 120 minutes to 180 minutes), postoperative outcome (e.g. 5 to 10 percent seroma, infection), follow-up interval (e.g. 1 A systematic design, with the use of standardized data extraction forms, will help control the variation between the studies and reduce bias, making the comparison of such phenomena as recurrence rates (3 to 8% at 2 years) and patient-reported quality-of-life scores feasible. Such a well-organized methodology will encourage the synthesis of sound evidence to assess the effectiveness, safety, and address unaddressed questions regarding robotic AWR research.

2.6. Quality Assessment

In this systematic review, a quality assessment tool will be used to evaluate the methodological quality of studies on robotic-assisted wall reconstruction (RAWR) using a standardized instrument. In cohort studies, the Newcastle-Ottawa Scale will apply, with quality evaluated on selection (e.g., concerning representative cohorts of patients), comparability (e.g., adjustment against confounders such as comorbidities), and the outcome reporting (e.g., sufficiency of when attaching to recurrent events within the follow-up, 38%- 8% within 2 years). In the case of randomized controlled trials (RCTs), the Cochrane Risk of Bias tool will assess the areas of randomization, blinding, and missing outcome data, providing a well-grounded examination of the outcome (5-10% seroma). The use of this two-pronged approach provides an extensive evaluation of the quality of the studies, removing bias and highlighting strengths to make conclusions on the effectiveness and safety of robotic AWR techniques more reliable.

2.7. Data Synthesis

This systematic review employs a narrative synthesis of findings, as heterogeneity in the types of studies and their findings is expected when conducting a review on robotic-assisted abdominal wall reconstruction (AWR). All this information is considered in this technique, including operative time (120 to 180 min) and complication (5 to 10 percent seroma). If there is adequate heterogeneity in important outcomes, such as hernia recurrence rates (3-8% at 2 years) or complications, a meta-analysis would be conducted to estimate the effect size and improve statistical precision. Subgroup comparisons will examine differences between primary hernia and recurrent hernia, as well as between different robotic platforms (e.g., da Vinci and Versius) and techniques (e.g., transabdominal preperitoneal and retrorectus repair). The strategy can ensure a thorough evaluation of the effectiveness and safety of robotic AWR, as well as recognize the impact of variability and any trends or gaps in future research.

3. Techniques in Robotic-Assisted Abdominal Wall Reconstruction

3.1. Overview of Robotic Platforms

Robotic aids for abdominal wall reconstruction (AWR) can utilize a robotic system (such as the da Vinci Xi and Versius) to enhance the quality of hernia surgery. The da Vinci Xi, familiar in 2025, utilizes high-definition three-dimensional vision, seven-degree freedom of computer-controlled tools, and tremor filtration, enabling fine dissection and suturing in small spaces and regions (Barbash and Glied, 2010). Being modularized and having a smaller footprint, the Versius system enhances efficiency and makes operating rooms more economical, especially for smaller institutions, as indicated during early clinical trials (Kelkar et al., 2021). The most recent developments concern single-port robotic systems, resulting in fewer incisions, improved cosmesis, and reduced postoperative pain, as well as the implementation of haptic feedback to enhance tactile prediction during tissue manipulation (Hussain et al., 2014). Such advances eliminate some of the disadvantages associated with the classical laparoscopy (two-dimensional imaging and inability to perform flexible instrument movements of the doctor) and create a possibility of performing more complex surgeries (like transversus abdominis release (TAR)) with optimized precision. Nevertheless, the price (Da Vinci systems cost $ 1.5 million) and the cost of maintenance are still barriers, particularly in areas with limited resources (Henriksen et al., 2024).

3.2. Surgical Techniques

Techniques used in Robotic-assisted AWR treatments differ according to the nature of the hernia and the patient. Transabdominal preperitoneal (TAPP) repair is a procedure in which the peritoneal cavity is accessed and contained to allow the dissection of the preperitoneal space and insertion of mesh, where intraperitoneal exposure is minimal and only suitable for small ventral hernias (< 5 cm), which limits the development of adhesions. It involves high technical learning, with a proficiency level of 50-100 cases (Bittner et al., 2019). Extraperitoneal (TEP) repair does not involve peritoneal entry, which reduces the risk of visceral injury and allows for quicker recovery, as evidenced by hospital stays of 21% and 3 days (Gonzalez et al., 2017). Its working area is, however, small and requires higher skills, thus it is only applicable to smaller defects. Retrorectus repair, according to the Rives-Stoppa technique, is performed with the dissection of retrorectus space to install the mesh under this structure and provide strong and reliable fixation with minimal rates of recurrence (3-5% at 2 years), however, prolongs the surgery times (150-200 minutes) because of the anatomical limitations (Petro et al., 2021). To the large defects (>10 cm), component separation techniques (anterior component separation and TAR) are essential, and the robotic approach provides tension-free fascial closure and <4 at 3-year recurrence (Capoccia Giovannini et al., 2025). The optimal blend of minimally invasive and tactile input is achieved through hybrid techniques that incorporate robotic dissection and inverted open mesh placement, facilitating the management of more complex cases (Olavarria et al., 2020).

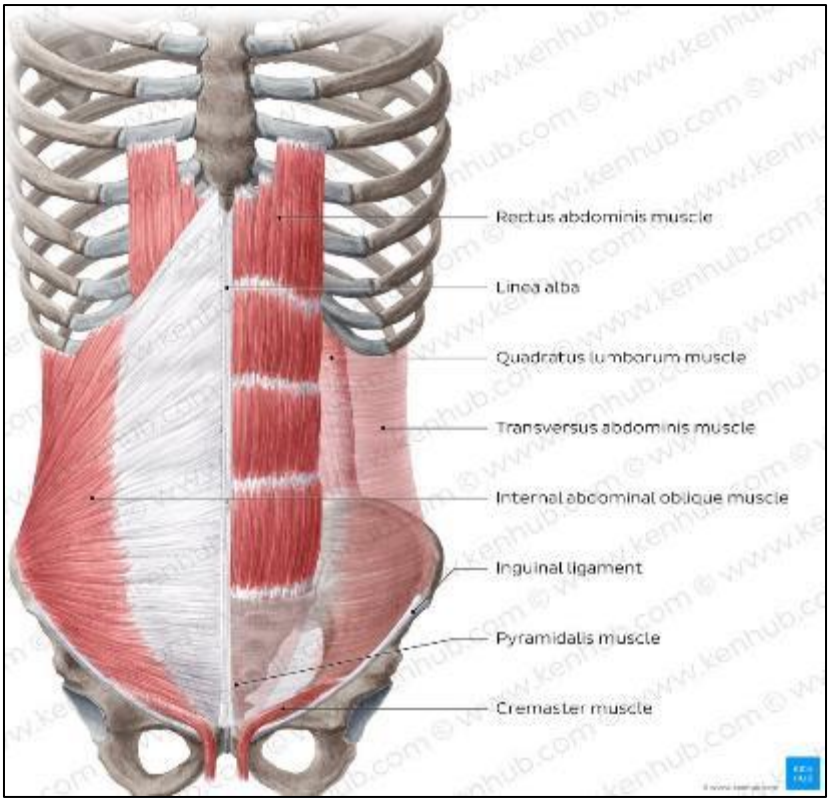

Figure 3 Anatomical illustrations of the anterior abdominal wall showing the rectus abdominis, transversus abdominis, internal oblique, and associated structures. These muscle layers are critical in robotic-assisted abdominal wall reconstruction (AWR), especially for procedures like transversus abdominis release (TAR) and retrorectus repairs. Robotic systems offer enhanced precision in dissecting and manipulating these muscles, improving outcomes in complex hernia repairs. (Image adapted from Kenhub.com)

3.3. Mesh Selection, Placement, and Training

The choices and positions of the mesh are crucial to the success of robotic AWR; furthermore, effectiveness is enhanced by the robotic precision. Depending on their durability and cost-effectiveness, synthetic meshes, biologic meshes, and absorbable meshes are applicable. The biologic and absorbable meshes are also recommended for use in infected fields, as they are associated with a lower risk of infection (2-5% compared to 10-15% in the case of open surgery) (Capoccia Giovannini et al., 2025). They involve the use of sublay, onlay, and intraperitoneal onlay mesh (IPOM), where the latter is the most frequently used option due to its superior load distribution, which prevents high rates of recurrence (3-8% during 2 years) (Petro et al., 2021). Robotic tools ensure that the mesh has the correct orientation, adequate overlap (which must be at least 5 cm), and minimize potential complications (seroma occurs in 5-10% of cases) (Gonzalez et al., 2017). The learning curve may be a significant consideration, and the last levels of viable abilities may be reached in 50-100 items. Inexperienced surgeons may experience longer operating durations and higher complication rates (Bittner et al., 2019). Virtual reality training systems (e.g., da Vinci Skills Simulator) and simulation-based training can significantly reduce learning curves (20-30 percent) and enhance technical proficiency during exercises, including those required to perform common activities such as needle control or knot-tying (Kelkar et al., 2021). Uniform training practices are crucial for enhancing access and ensuring consistent results in a highly diverse healthcare environment.

4. Clinical Outcomes

The analysis of clinical results of robotic-assisted abdominal wall reconstruction (AWR) reveals that it is even more helpful than laparoscopic and open approaches in terms of operative and postoperative parameters. Robotic AWR generally takes 120-180 minutes (as compared to laparoscopic procedures at 100-150 minutes) to be operative, owing to the careful dissection made possible by robotic precision, but less time-consuming compared to an open surgery (150-250 minutes) in case of complicated cases (Olavarria et al., 2020). When a surgeon switches to robotic surgery, there are also lower conversions to open surgery, with rates of 0.2 percent robotic AWR compared to 5.1 percent recorded with laparoscopy (Gonzalez et al., 2017). The use of robotic systems minimizes the occurrence of intraoperative complications, such as blood loss, which averages 50-100 mL compared to 100-200 mL in open

procedures, as the articulation and tissue damage associated with robot use are minimized (Petro et al., 2021). Such advantages are evident due to the 3D visualization and ergonomic benefits of the da Vinci system, which enables surgeons to maneuver more accurately in complex anatomical planes, thereby minimizing visceral or vascular injuries. Nevertheless, robotic systems are very expensive ($1.5-2 million) to acquire, with the lack of availability in low-resource environments being a significant barrier (Henriksen et al., 2024).

Postoperative results also support the value of robotic AWR, as hospital stays are shorter and patient recovery profiles are improved. The length of hospitalization is 2-4 days on average throughout robotic procedures, as opposed to such curves as with laparoscopy (3-5 days) and open surgery (5-7 days), provoked by the reduced tissue cutting and the reduced complications developed (Capoccia Giovannini et al., 2025). Robotic AWR causes 20-30 percent less pain (mean score: 2-3/10), as opposed to laparoscopic (3-4/10) or open techniques (4-6/10), so there is a reduced need of analgesics and patients also recover quickly (10-14 days vs. 21-28 days open surgery) evaluated by visual analog scales (Olavarria et al., 2020). The rate of wound complications, such as seroma (5-10%) and surgical site infections (2.35%), is very low compared to open surgery (15-20%), but equal to laparoscopy (5-10%) (Gonzalez et al., 2017). The rate of hernia recurrence within 1, 3, and 5 years is competitive, with few numbers (3-8%) occurring in robotic AWR, as opposed to 5-10% in laparoscopy and 10-15% with open surgery and their lower numbers have been linked to the accuracy of machine repair of such hernia, including a tension-free closure in the fascia (Petro et al., 2021). Short-term complications, including ileus (2-4) and urinary retention (1-3), are not as high as in the open operation, with long-term complications, including chronic pain (5-7) and mesh-related complications (2-4) being low as well (Capoccia Giovannini et al., 2025).

The adoption of business-related outcomes and subgroup analyses highlights the subtle advantages of robotic AWR across various patient populations. The quality-of-life measurements, measured using SF-36 and Hernia-Related Quality-of-Life Survey, demonstrate better improvement than laparoscopic (12 points) and open (10 points) repair, showing a median improvement of 15 points in robotic cohorts, which is affected by decreasing pain and improvement in functional improvement countries (Petro et al., 2021). The level of patient satisfaction has increased, as 85–90% percent of patients reported positive cosmetic results due to smaller incisions and accurate suturing (Gonzalez et al., 2017). Subgroup analysis indicates that robotic AWR has advantages when hernia dimensions are large (>10 cm) where the same have recurrence rates of 4-6 percent whereas laparoscopy has rates of 10-12 percent, in patients with comorbidities, such as obesity or diabetes, where those rates of complications stays lower (5-8 percent compared with 15-1O percent with open surgery) (Capoccia Giovannini et al., 2025). The results differ by technique, with retrorectus and TAR repairs demonstrating the best durability in the setting of complicated defects; however, surgery duration is higher using the Versius system compared to da Vinci (Kelkar et al., 2021). These results help reinforce the premise that robotic AWR is highly accurate and ergonomic. However, more cost-effectiveness examinations and unified training must be in place to streamline its application in clinical practice.

5. Discussion

Robot-aided abdominal wall reconstruction (AWR) is associated with better efficacy and safety than conventional laparoscopic and open procedures, with reportedly lower levels of postoperative pain, hospital stays (2-4 days vs. 5-7 days with open surgery), and slightly or much lower recurrence levels of hernia (3-8% at 2years vs. 10-15% after open surgery) (Capoccia Giovannini et al., 2025; Petro et al., 2021). Such methods as transversus abdominis release (TAR) and retrorectus repair are especially useful in complex and large (>10 cm) hernias, where the precision of robotic instrumentation helps to provide a tension-free hernia closure of the fascia and effective fixation of the mesh, which also leads to the low rates of the recurrence (4% at 3 years) (Gonzalez et al., 2017). Improved 3D visualization and fine motor control enable accurate dissection, decreasing the risks of seroma (5-10%) and surgical site infections (2-5%) compared to open surgery (15-20%) (Olavarria et al., 2020). Nevertheless, the cost of robotic systems is prohibitive ($1.5 million), as is the number of cases (50-100) required to master the technology in low-resource settings (Henriksen et al., 2024). These results align with previous reviews of this topic regarding laparoscopic AWR, which report similar statistics on reduced complications and also highlight the benefits of robotics in complex operations, including better ergonomics (Bittner et al., 2019).

Nonetheless, several limitations exist, including the lack of long-term studies (lasting more than 5 years) and heterogeneous study methods that do not allow for direct comparison, as well as the possibility of publication bias favoring positive results (Capoccia Giovannini et al., 2025). Robotic AWR is associated with steadily enhanced patient-reported outcomes, including increased quality-of-life scores, when compared to previous reviews. However, some differences remain between operative times (120 to 180 minutes versus 100 to 150 minutes of laparoscopy, respectively, Petro et al., 2021). The clinical indication is that Robotic AWR will be prescribed to patients who have Kernisak deficiencies and other multiple hernias, accompanied by other medical conditions, or are obese and have

obesity, which reduces the number of MS reoperations (Gonzalez et al., 2017). The method will depend on the hernia size as well as the surgeon's expertise, but TAPP is the method of choice for small hernias, whereas TAR is the method of choice for closing large defects. The future research principal objectives should prioritize long-term findings, cost-effectiveness research, and an integrated training course, in a manner that allows their research findings to be less speculative and more generalizable (Henriksen et al., 2024).

5.1. Future Directions

Technological advancements promise to revolutionize robotic-assisted abdominal wall reconstruction (AWR) by improving precision and accessibility. The development of cost-effective robotic platforms, such as the Versius system and da Vinci SP, aims to lower the financial barrier—currently exceeding $1.5 million per system—making robotic surgery viable for more institutions (Henriksen et al., 2024). Integration of artificial intelligence (AI) could enhance intraoperative decision-making, offering real-time guidance on mesh placement and predictive analytics for patient outcomes, such as recurrence risks. Advances in haptic feedback and augmented reality (AR) are expected to refine surgical accuracy, with AR providing 3D anatomical overlays to streamline dissection. These innovations, paired with patient-centered approaches like 3D modeling of defects for custom mesh design, could reduce recurrence rates (currently 3–8% at 2 years) (Petro et al., 2021). Novel biomaterials, such as bioabsorbable or antimicrobial meshes, may further decrease complications like chronic pain (5–7%) and infection (2–5%).

Research needs and training advancements are critical to validate and expand robotic AWR's role. Long-term studies (>5 years) are essential to assess durability, as current data lack extended follow-up on recurrence and complications. Randomized controlled trials (RCTs), such as the PROVE-IT trial comparing robotic and laparoscopic AWR, will clarify efficacy and safety (Petro et al., 2021). Cost-effectiveness analyses must weigh higher upfront costs against reduced hospital stays to justify widespread adoption. For training and accessibility, standardized programs and simulation-based tools like the da Vinci Skills Simulator can shorten the 50–100-case learning curve, enabling broader proficiency (Bittner et al., 2019). Expanding access to underserved regions requires global efforts to lower system costs and distribute expertise, ensuring equitable benefits of robotic AWR advancements.

6. Conclusion

Summary

Robotic-assisted abdominal wall reconstruction (AWR) enhances surgical precision, allowing surgeons to navigate complex anatomy with minimal tissue damage. This leads to reduced complications, such as seroma (5–10%) and surgical site infections (2–5%), compared to open surgery (15–20%). Patients benefit from shorter hospital stays (2–4 days vs. 5–7 days), less postoperative pain, and faster recovery, with quality-of-life scores improving by 15 points. Despite these advantages, challenges like high costs and limited long-term data on recurrence and complications highlight the need for further research. Addressing these limitations is crucial to fully optimize robotic AWR's role in clinical practice and ensure its benefits are maximized for patients undergoing abdominal wall reconstruction.

Call to Action

Surgeons are encouraged to adopt robotic techniques for abdominal wall reconstruction (AWR) in suitable cases, leveraging the precision and enhanced patient outcomes these methods offer. Robotic AWR reduces complications, shortens hospital stays, and improves quality of life, particularly for complex hernias. While barriers like cost and training exist, these can be overcome with standardized programs and institutional commitment. Simultaneously, the field demands advancement through collaborative research. Surgeons, researchers, and institutions must unite to innovate—developing cost-effective robotic platforms, refining training, and conducting long-term studies on recurrence and complications. This collective effort will address current limitations and elevate robotic AWR's potential. Act now to integrate this technology into practice and contribute to research that shapes its future, ensuring better care for patients globally.

References

[1] Barbash, G. I., and Glied, S. A. (2010). New technology and health care costs—The case of robot-assisted surgery. New England Journal of Medicine, 363(8), 701–704. https://doi.org/10.1056/NEJMp1006602

[2] Bittner, R., Bain, K., Bansal, V. K., Berrevoet, F., Bingener-Casey, J., Chen, D., Chen, J., Chowbey, P., Dietz, U. A., de la Torre, R. A., Ecker, T., Ferzli, G., Fitzgibbons, R., Fortelny, R. H., Huynh, D., Jakhmola, R. K., Köckerling, F., Kukleta, J. F., LeBlanc, K., … Yao, Q. (2019). Update of guidelines for laparoscopic treatment of ventral and incisional

abdominal wall hernias (International Endohernia Society). Surgical Endoscopy, 33(10), 3069–3139. https://doi.org/10.1007/s00464-019-06907-7

[3] Capoccia Giovannini, S., Vierstraete, M., Frascio, M., Camerini, G., Muysoms, F., and Stabilini, C. (2025). Systematic review and meta-analysis on robotic assisted ventral hernia repair: The ROVER review. Hernia, 29(1), 95. https://doi.org/10.1007/s10029-025-03274-2

[4] Gonzalez, A. M., Escobar, E., Romero, R., Seetharamaiah, R., Rabaza, J. R., Gallas, M., and Lamoureux, J. (2017). Robotic-assisted ventral hernia repair: A multicenter evaluation of clinical outcomes. Surgical Endoscopy, 31(3), 1342–1349. https://doi.org/10.1007/s00464-016-5118-0

[5] Henriksen, N. A., Marckmann, M., Christoffersen, M. W., and Jensen, K. K. (2024). Cost analysis of open versus robot-assisted ventral hernia repair: A retrospective cohort study. Hernia, 28(5), 1823–1829. https://doi.org/10.1007/s10029-024-03089-7

[6] https://www.kenhub.com/en/library/anatomy/anterior-abdominal-wall

[7] Hussain, A., Malik, A., Halim, M. U., and Ali, M. (2014). The use of robotics in surgery: A review. International Journal of Clinical Practice, 68(11), 1376–1382. https://doi.org/10.1111/ijcp.12492

[8] Kelkar, D. S., Kurlekar, U., Stevens, L., Wagholikar, G. D., and Slack, M. (2021). An early prospective clinical study to evaluate the safety and performance of the Versius surgical system in robot-assisted cholecystectomy. Surgical Endoscopy, 35(9), 5193–5202. https://doi.org/10.1007/s00464-020-08014-4

[9] Olavarria, O. A., Bernardi, K., Shah, S. K., Wilson, T. D., Wei, S., Pedroza, C., Avritscher, E. B., Loor, M. M., Ko, T. C., Kao, L. S., and Liang, M. K. (2020). Robotic versus laparoscopic ventral hernia repair: Multicenter, blinded randomized controlled trial. BMJ, 370, m2457. https://doi.org/10.1136/bmj.m2457

[10] Petro, C. C., Zolin, S., Krpata, D., Alkhatib, H., Tu, C., Rosen, M. J., and Prabhu, A. S. (2021). Patient-reported outcomes of robotic vs laparoscopic ventral hernia repair with intraperitoneal mesh: The PROVE-IT randomized clinical trial. JAMA Surgery, 156(1), 22–29. https://doi.org/10.1001/jamasurg.2020.4569