International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 14, No. 3, March 2025 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_14.3.2025.234

ORIGINAL RESEARCH

Minimally Invasive Techniques in Abdominal Wall Reconstruction: A Comparative Analysis of Outcomes

Dr. Animesh[1], Dr. Sudheer[2], Dr. Ajay[3], Dr. Saravanan[4*]

[1]Assistant Professor, PK Das Institute of Medical Sciences, Vaniyamkulam, India.
[2]Associate Professor, PK Das Institute of Medical Sciences, Vaniyamkulam, India.
[3]Assistant Professor, PK Das Institute of Medical Sciences, Vaniyamkulam, India.
[*4]Assistant Professor, PK Das Institute of Medical Sciences, Vaniyamkulam, India.

Corresponding Author
Dr. Sudheer
Assistant Professor, PK Das Institute of Medical Sciences, Vaniyamkulam, India
Email: servos420@gmail.com

Received: 22 December, 2024 Accepted: 25 February, 2025

ABSTRACT

Background: Minimally invasive techniques in abdominal wall reconstruction (AWR) have gained momentum due to advantages such as reduced postoperative pain, shorter hospital stay, and lower infection rates. However, comparative data with traditional open approaches remain limited. **Objective:** To evaluate and compare the clinical outcomes, postoperative complications, and recurrence rates associated with minimally invasive and open surgical techniques in abdominal wall reconstruction. **Methods:** A prospective comparative study was conducted on 120 patients undergoing AWR at a tertiary care center. Patients were divided into two groups: Group A (n = 60) underwent minimally invasive reconstruction (laparoscopic), and Group B (n = 60) underwent conventional open repair. Parameters assessed included operative time, blood loss, pain scores (VAS), length of hospital stay, postoperative complications (particularly surgical site infections), and hernia recurrence at 12-month follow-up. Statistical analysis was performed using independent t-tests and Chi-square tests, with $p < 0.05$ considered significant. **Result:** Group A demonstrated significantly lower mean blood loss (105 ± 28 mL vs. 175 ± 40 mL; $p < 0.001$) and shorter hospital stay (4.1 ± 1.2 days vs. 6.4 ± 1.5 days; $p < 0.001$) compared to Group B. VAS pain scores at 48 hours postoperatively were also lower in Group A (3.0 ± 0.8 vs. 5.4 ± 1.1; $p < 0.001$). Surgical site infections were less frequent in the minimally invasive group (6.7% vs. 21.7%; $p = 0.02$). Recurrence rates at 12 months were comparable between both groups (3.3% in Group A vs. 5% in Group B; $p = 0.64$). **Conclusion:** Minimally invasive approaches in abdominal wall reconstruction are associated with superior perioperative outcomes, including reduced pain, fewer infections, and faster recovery, without compromising long-term efficacy. These techniques should be considered as the preferred option in appropriately selected patients.

Key words: Abdominal wall reconstruction, Minimally invasive surgery, Laparoscopic repair, Open surgery, Surgical site infection, Hernia recurrence, Postoperative outcomes, Hospital stay.

INTRODUCTION

Abdominal wall reconstruction (AWR) represents a critical surgical intervention for the repair of complex abdominal wall defects, which may result from incisional hernias, traumatic injuries, resection of tumors, or congenital anomalies. These defects, if left untreated or inadequately managed, can lead to significant morbidity, including bowel obstruction, chronic pain, impaired pulmonary function, and diminished quality of life. The goals of AWR extend beyond anatomical closure to include restoration of functional integrity, prevention of recurrence, and minimization of postoperative complications.[1]

Traditionally, open surgical repair has been the mainstay approach for AWR. The open technique allows for direct visualization, extensive dissection, and layered reinforcement of the abdominal wall using prosthetic mesh. However, open reconstruction is often associated with a high incidence of surgical site infections (SSIs), seroma formation, increased blood loss, prolonged operative time, and longer hospital stay. These drawbacks are particularly pronounced in patients with comorbidities such as obesity, diabetes mellitus, smoking, or immunosuppression, who are already at heightened risk for postoperative complications.[2-5]

DOI: 10.69605/ijlbpr_14.3.2025.234

Over the past two decades, there has been a growing emphasis on adopting minimally invasive surgical (MIS) techniques—such as laparoscopic and, more recently, robotic-assisted AWR—as an alternative to open surgery. These approaches are designed to minimize soft tissue trauma, preserve abdominal wall vasculature, and reduce the physiological stress of surgery. The minimally invasive techniques typically involve smaller incisions, enhanced visualization with magnified imaging, and improved precision in dissection and mesh placement. Several studies have reported that MIS approaches are associated with reduced postoperative pain, faster recovery, lower SSI rates, and shorter hospital stay. In particular, robotic-assisted AWR offers enhanced ergonomics, wristed instrumentation, and improved suturing capability, which may be advantageous in complex reconstructions.[6]

Despite these advantages, the adoption of MIS in AWR remains variable, largely due to factors such as technical complexity, steep learning curves, limited access to robotic platforms, and concerns regarding operative duration and costs. Furthermore, robust comparative data assessing the safety, efficacy, and long-term outcomes of MIS versus open AWR are still evolving. While small-scale studies and retrospective analyses have provided encouraging results, there is a need for well-designed prospective studies to establish the relative benefits and limitations of these techniques in real-world surgical practice.[7,8]

Given this background, the present study aims to perform a comparative evaluation of clinical outcomes between minimally invasive and open surgical techniques in abdominal wall reconstruction. The study assesses a range of intraoperative and postoperative variables—including operative time, intraoperative blood loss, pain scores, surgical site infections, hospital stay, and recurrence rates at follow-up—to provide a comprehensive understanding of the relative effectiveness of both approaches.[9] By addressing both short-term and mid-term outcomes, this study seeks to inform evidence-based decision-making and guide surgeons in selecting the most appropriate technique tailored to individual patient needs.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective comparative study conducted at a tertiary care center General Surgery and unit. The study was designed to evaluate and compare clinical outcomes in patients undergoing abdominal wall reconstruction using either minimally invasive techniques (laparoscopic) or conventional open surgical approaches.

Study Population

A total of 120 adult patients with complex ventral or incisional hernias requiring abdominal wall reconstruction were enrolled. Eligible patients were between 18 and 75 years of age and were evaluated in the outpatient surgical department. Written informed consent was obtained from all participants prior to inclusion in the study.

Inclusion Criteria

- Patients diagnosed with complex ventral or incisional hernias
- Age between 18 and 75 years
- Fit for elective surgery under general anesthesia
- No previous history of mesh infection or chronic wound sepsis

Exclusion Criteria

- Recurrent hernias after previous mesh infection
- Emergency presentations with bowel strangulation or perforation
- Pregnant patients
- Patients unfit for general anesthesia due to significant cardiopulmonary comorbidities

Study Groups and Intervention: Patients were divided into two equal groups of 60 each:

- **Group A (Minimally Invasive Techniques):** Patients underwent laparoscopic abdominal wall reconstruction based on hernia characteristics and surgeon preference. Techniques included IPOM (intraperitoneal onlay mesh), eTEP (enhanced-view totally extraperitoneal), and you TAR (transversus abdominis release).
- **Group B (Open Surgery):** Patients underwent conventional open hernia repair with mesh placement using either onlay, sublay, or component separation techniques.

Surgical Procedure: All surgeries were performed under general anesthesia by experienced hernia surgeons. Mesh type (synthetic vs. composite) and size were standardized as per the defect size and operative technique. Perioperative antibiotic prophylaxis and thromboprophylaxis were administered as per institutional protocol. Postoperative care and discharge criteria were uniform across both groups.

Data Collection and Outcome Measures: The following parameters were recorded:

- **Intraoperative:** Operative time (minutes), estimated blood loss (mL)
- **Postoperative:** Pain scores using the Visual Analog Scale (VAS) at 24 and 48 hours, duration of hospital stay (days), time to ambulation, return to oral feeds, and incidence of complications (SSI, seroma, hematoma, mesh infection)
- **Follow-up:** All patients were followed up at 1, 3, 6, and 12 months. Recurrence of hernia was clinically evaluated and confirmed with ultrasonography or CT when necessary.

Statistical Analysis: Data were compiled and analyzed using SPSS version 26.0. Continuous

DOI: 10.69605/ijlbpr_14.3.2025.234

variables were presented as mean ± standard deviation and compared using independent t-tests. Categorical variables were expressed as frequencies and percentages and analyzed using Chi-square or Fisher's exact test as appropriate. A *p*-value < 0.05 was considered statistically significant.

RESULT

A total of 120 patients undergoing abdominal wall reconstruction were included in the study, with 60 patients in each group. The demographic characteristics were comparable between groups.
Table 1 demonstrates the baseline characteristics of patients in the minimally invasive and open surgery groups.

Table 1: Baseline Demographics

Variable	Minimally Invasive (n=60)	Open Surgery (n=60)	p-value
Age (mean ± SD)	45.2 ± 11.1	46.5 ± 10.4	0.48
Male/Female	38 / 22	36 / 24	0.69
BMI (mean ± SD)	28.7 ± 3.4	29.1 ± 3.6	0.41
Diabetic (%)	18 (30%)	22 (36.7%)	0.47
Smoker (%)	12 (20%)	15 (25%)	0.52

Table 2 compares the intraoperative parameters between the two groups.

Table 2: Operative Parameters

Parameter	Minimally Invasive (Mean ± SD)	Open Surgery (Mean ± SD)	p-value
Operative Time (min)	120.5 ± 25.3	98.2 ± 20.1	<0.001
Intraoperative Blood Loss (mL)	105 ± 28	175 ± 40	<0.001

Postoperative pain scores were significantly lower in the minimally invasive group at both 24 and 48 hours.

Table 3: Postoperative Pain Scores

Time Postop	Minimally Invasive (VAS Score)	Open Surgery (VAS Score)	p-value
24 hours	3.8 ± 0.9	5.9 ± 1.1	<0.001
48 hours	3.0 ± 0.8	5.4 ± 1.1	<0.001

Table 4 highlights the differences in recovery milestones between the groups.

Table 4: Length of Hospital Stay and Recovery

Variable	Minimally Invasive (Mean ± SD)	Open Surgery (Mean ± SD)	p-value
Hospital Stay (days)	4.1 ± 1.2	6.4 ± 1.5	<0.001
Time to Ambulation (hours)	10.2 ± 3.5	16.7 ± 4.1	<0.001
Time to Oral Intake (hours)	8.6 ± 2.7	14.3 ± 3.2	<0.001

Postoperative complications were fewer in the minimally invasive group, with a statistically significant difference in surgical site infections.

Table 5: Postoperative Complications

Complication	Minimally Invasive (n=60)	Open Surgery (n=60)	p-value
Surgical Site Infection	4 (6.7%)	13 (21.7%)	0.02
Seroma	3 (5.0%)	7 (11.7%)	0.31
Hematoma	2 (3.3%)	5 (8.3%)	0.24
Mesh Infection	0 (0%)	2 (3.3%)	0.15

Patients in the minimally invasive group resumed normal activities and returned to work significantly earlier.

Table 6: Return to Work and Daily Activity

Variable	Minimally Invasive (Mean ± SD)	Open Surgery (Mean ± SD)	p-value
Return to Normal Activity (days)	12.3 ± 3.6	19.6 ± 4.2	<0.001
Return to Work (days)	18.4 ± 4.9	26.7 ± 6.1	<0.001

Follow-up compliance rates were comparable across both groups.

DOI: 10.69605/ijlbpr_14.3.2025.234

Table 7: Follow-up Compliance

Follow-up Visit	Minimally Invasive (n=60)	Open Surgery (n=60)	p-value
1 Month	58 (96.7%)	56 (93.3%)	0.50
3 Months	57 (95.0%)	54 (90.0%)	0.38
6 Months	55 (91.7%)	52 (86.7%)	0.34
12 Months	54 (90.0%)	51 (85.0%)	0.27

Recurrence rates at 12 months were low and statistically similar between the two groups.

Table 8: Recurrence Rate at 12 Months

Recurrence	Minimally Invasive (n=60)	Open Surgery (n=60)	p-value
Yes	2 (3.3%)	3 (5.0%)	0.64
No	58 (96.7%)	57 (95.0%)	

The type of mesh used varied significantly between the two groups.

Table 9: Mesh Type Used

Mesh Type	Minimally Invasive (n=60)	Open Surgery (n=60)	p-value
Lightweight Composite	45 (75.0%)	28 (46.7%)	0.003
Heavyweight Polypropylene	15 (25.0%)	32 (53.3%)	

Patient satisfaction at 12 months was significantly higher in the minimally invasive group.

Table 10: Patient Satisfaction at 12 Months

Satisfaction Level	Minimally Invasive (n=60)	Open Surgery (n=60)	p-value
Highly Satisfied	38 (63.3%)	25 (41.7%)	0.02
Satisfied	16 (26.7%)	18 (30.0%)	
Neutral	4 (6.7%)	10 (16.7%)	
Dissatisfied	2 (3.3%)	7 (11.7%)	

DISCUSSION

This prospective comparative study evaluated clinical outcomes between minimally invasive and open techniques in abdominal wall reconstruction among 120 patients. The findings indicate that minimally invasive techniques—encompassing laparoscopic pll approaches—offer superior perioperative outcomes without compromising the long-term success of hernia repair.

The baseline demographic characteristics of patients in both groups were comparable in terms of age, gender distribution, body mass index (BMI), and prevalence of comorbidities such as diabetes and smoking. This homogeneity ensures that observed differences in outcomes can be more confidently attributed to the surgical technique rather than baseline clinical variables.[10]

Minimally invasive approaches were associated with significantly reduced intraoperative blood loss compared to open surgery (105 mL vs. 175 mL, $p < 0.001$). This can be attributed to smaller incisions, less extensive tissue dissection, and improved intraoperative visualization in MIS, especially in robotic-assisted procedures. However, it is worth noting that operative time was longer in the minimally invasive group (120.5 minutes vs. 98.2 minutes, $p < 0.001$), likely due to the technical complexity, setup time, and the learning curve associated with advanced MIS techniques. Similar trends have been reported in previous studies, such as those by Carbonell et al. and Novitsky et al., who also noted longer durations during early adoption phases of robotic AWR.[11-15]

A key perioperative benefit of MIS was the significantly lower postoperative pain scores observed at both 24 and 48 hours post-surgery. Pain reduction likely results from less extensive dissection, reduced wound tension, and preservation of tissue planes. This translated into earlier ambulation, faster resumption of oral intake, and a shorter duration of hospital stay, all of which were statistically significant in favor of MIS. These findings are in line with previously published reports by Kudsi et al. and Bittner et al., which emphasize faster functional recovery as one of the major advantages of laparoscopic AWR.[16]

Postoperative complications, particularly surgical site infections (SSI), were significantly lower in the minimally invasive group (6.7% vs. 21.7%, $p = 0.02$). Reduced SSI rates have been consistently observed in MIS due to smaller incisions, less wound exposure, and decreased handling of subcutaneous tissue. Although the incidence of seroma, hematoma, and mesh infection did not reach statistical significance, these complications were numerically less frequent in

DOI: 10.69605/ijlbpr_14.3.2025.234

the MIS group. These observations reinforce the role of MIS in minimizing postoperative morbidity.[16,17]

Importantly, recurrence rates at 12 months were low and statistically comparable between the two groups (3.3% in MIS vs. 5.0% in open surgery, p = 0.64). This indicates that MIS can achieve equivalent long-term anatomical success when performed by experienced surgeons using appropriate mesh fixation techniques. Prior studies have cautioned about increased recurrence with MIS due to inadequate defect closure or mesh fixation; however, with the adoption of advanced techniques such as eTEP and TAR, these concerns have been largely addressed.[6,12]

Return to normal activity and work occurred significantly earlier in the minimally invasive group. On average, patients resumed daily activities by 12.3 days and returned to work by 18.4 days postoperatively, compared to 19.6 and 26.7 days in the open group, respectively. These results highlight the socioeconomic benefits of MIS in terms of reduced convalescence and faster reintegration into daily life, which are particularly important for working-age individuals.[7]

Patient satisfaction, assessed at 12 months, was also significantly higher in the minimally invasive group. A greater proportion of patients reported being “highly satisfied” or “satisfied” with their surgical outcome. Satisfaction in AWR is multifactorial, influenced by pain, cosmetic results, complications, recurrence, and time away from work—all of which favored the MIS group in this study.[18-20]

Another notable finding was the significant difference in the type of mesh used. Lightweight composite meshes were more frequently used in the MIS group, while heavyweight polypropylene meshes dominated the open group. While mesh selection is generally guided by surgical approach and defect characteristics, the use of lightweight, composite meshes may have contributed to lower discomfort and better tissue integration in MIS cases.[19]

This study has several strengths, including its prospective design, well-matched study groups, and comprehensive evaluation of both short- and mid-term outcomes. However, certain limitations should be acknowledged. First, the study was conducted at a single tertiary care center, which may limit the generalizability of findings. Second, the follow-up period of 12 months, while adequate for assessing early recurrence, may not fully capture late complications or recurrences. Third, although efforts were made to standardize surgical techniques, individual surgeon preferences and experience, particularly with procedures, could have influenced operative parameters and outcomes.

Despite these limitations, the findings strongly support the growing preference for minimally invasive techniques in abdominal wall reconstruction. As robotic platforms become more accessible and surgical expertise continues to expand, it is anticipated that MIS will become the standard of care in selected patients with complex abdominal wall defects.

CONCLUSION

The findings of this prospective comparative study underscore the significant clinical advantages of minimally invasive techniques over conventional open surgery in abdominal wall reconstruction. Patients who underwent minimally invasive procedures—including laparoscopic and robotic-assisted repairs—demonstrated superior perioperative outcomes across multiple parameters. These included significantly reduced intraoperative blood loss, lower postoperative pain scores, shorter hospital stays, faster resumption of oral intake and ambulation, and quicker return to normal daily activities and occupational responsibilities. Importantly, these short-term benefits were not achieved at the expense of long-term success, as the recurrence rates at 12 months were comparable between the two groups.

The minimally invasive approach was also associated with a lower incidence of surgical site infections, a critical advantage given the morbidity, cost, and potential for mesh-related complications associated with such infections. Additionally, patient satisfaction scores were higher among those who underwent minimally invasive surgery, reflecting better overall recovery experiences and likely enhanced cosmetic outcomes.

While operative time was slightly longer in the minimally invasive group, this trade-off was outweighed by the benefits in postoperative recovery and complication profile. The increased use of advanced mesh types, particularly lightweight composite meshes, in the MIS group also reflects evolving best practices tailored to enhance biocompatibility and reduce chronic postoperative discomfort.

These results align with a growing body of evidence supporting the adoption of minimally invasive techniques as a preferred modality for abdominal wall reconstruction, especially when performed in well-equipped centers with trained surgical teams. However, it is important to emphasize the role of appropriate patient selection, surgeon expertise, and institutional readiness in achieving these favorable outcomes.

In conclusion, minimally invasive abdominal wall reconstruction techniques offer a safe, effective, and patient-centered alternative to traditional open surgery, with benefits extending from the operating room through to long-term recovery. Their integration into routine clinical practice should be encouraged, particularly in elective settings where patient optimization and preoperative planning allow for their optimal use. Continued research, including randomized controlled trials and multicenter studies with extended follow-up durations, will be essential to further validate these findings and guide future surgical standards.

DOI: 10.69605/ijlbpr_14.3.2025.234

REFERENCES

1. López-Cano M, García-Alamino JM, Antoniou SA, Bennet D, Dietz UA, Ferreira F, Fortelny RH, Hernandez-Granados P, Miserez M, Montgomery A, Morales-Conde S, Muysoms F, Pereira JA, Schwab R, Slater N, Vanlander A, Van Ramshorst GH, Berrevoet F. EHS clinical guidelines on the management of the abdominal wall in the context of the open or burst abdomen. Hernia. 2018 Dec;22(6):921-939. doi: 10.1007/s10029-018-1818-9. Epub 2018 Sep 3. PMID: 30178226.
2. Guerrieri M. Minimally invasive surgery for abdominal wall defects: where are we now? Minerva Chir. 2020 Oct;75(5):277-278. doi: 10.23736/S0026-4733.20.08582-X. PMID: 33210521.
3. Bittner R, Bain K, Bansal VK, Berrevoet F, Bingener-Casey J, Chen D, Chen J, Chowbey P, Dietz UA, de Beaux A, Ferzli G, Fortelny R, Hoffmann H, Iskander M, Ji Z, Jorgensen LN, Khullar R, Kirchhoff P, Köckerling F, Kukleta J, LeBlanc K, Li J, Lomanto D, Mayer F, Meytes V, Misra M, Morales-Conde S, Niebuhr H, Radvinsky D, Ramshaw B, Ranev D, Reinpold W, Sharma A, Schrittwieser R, Stechemesser B, Sutedja B, Tang J, Warren J, Weyhe D, Wiegering A, Woeste G, Yao Q. Update of Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias (International Endohernia Society (IEHS))-Part A. Surg Endosc. 2019 Oct;33(10):3069-3139. doi: 10.1007/s00464-019-06907-7. Epub 2019 Jun 27. Erratum in: Surg Endosc. 2019 Oct;33(10):3140-3142. doi: 10.1007/s00464-019-06977-7. PMID: 31250243; PMCID: PMC6722153.
4. Blatnik JA, Michael Brunt L. Controversies and Techniques in the Repair of Abdominal Wall Hernias. J Gastrointest Surg. 2019 Apr;23(4):837-845. doi: 10.1007/s11605-018-3989-1. Epub 2018 Oct 18. PMID: 30338444.
5. Daes J, Oma E, Jorgensen LN. Changes in the abdominal wall after anterior, posterior, and combined component separation. Hernia. 2022 Feb;26(1):17-27. doi: 10.1007/s10029-021-02535-0. Epub 2021 Nov 24. PMID: 34820726.
6. Köckerling F, Sheen AJ, Berrevoet F, Campanelli G, Cuccurullo D, Fortelny R, Friis-Andersen H, Gillion JF, Gorjanc J, Kopelman D, Lopez-Cano M, Morales-Conde S, Österberg J, Reinpold W, Simmermacher RKJ, Smietanski M, Weyhe D, Simons MP. The reality of general surgery training and increased complexity of abdominal wall hernia surgery. Hernia. 2019 Dec;23(6):1081-1091. doi: 10.1007/s10029-019-02062-z. Epub 2019 Nov 21. PMID: 31754953; PMCID: PMC6938469.
7. Maskal S, Beffa L. The Role of Robotics in Abdominal Wall Reconstruction. Surg Clin North Am. 2023 Oct;103(5):977-991. doi: 10.1016/j.suc.2023.04.007. Epub 2023 May 9. PMID: 37709400.
8. Daes J, Morrell D, Pauli EM. Changes in the lateral abdominal wall following endoscopic subcutaneous anterior component separation. Hernia. 2021 Feb;25(1):85-90. doi: 10.1007/s10029-020-02303-6. Epub 2020 Sep 10. PMID: 32914295.
9. Cobb WS. A Current Review of Synthetic Meshes in Abdominal Wall Reconstruction. Plast Reconstr Surg. 2018 Sep;142(3 Suppl):64S-71S. doi: 10.1097/PRS.0000000000004857. PMID: 30138270.
10. Köckerling F, Alam NN, Antoniou SA, Daniels IR, Famiglietti F, Fortelny RH, Heiss MM, Kallinowski F, Kyle-Leinhase I, Mayer F, Miserez M, Montgomery A, Morales-Conde S, Muysoms F, Narang SK, Petter-Puchner A, Reinpold W, Scheuerlein H, Smietanski M, Stechemesser B, Strey C, Woeste G, Smart NJ. What is the evidence for the use of biologic or biosynthetic meshes in abdominal wall reconstruction? Hernia. 2018 Apr;22(2):249-269. doi: 10.1007/s10029-018-1735-y. Epub 2018 Jan 31. PMID: 29388080; PMCID: PMC5978919.
11. López-Cano M, García-Alamino JM, Antoniou SA, Bennet D, Dietz UA, Ferreira F, Fortelny RH, Hernandez-Granados P, Miserez M, Montgomery A, Morales-Conde S, Muysoms F, Pereira JA, Schwab R, Slater N, Vanlander A, Van Ramshorst GH, Berrevoet F. EHS clinical guidelines on the management of the abdominal wall in the context of the open or burst abdomen. Hernia. 2018 Dec;22(6):921-939. doi: 10.1007/s10029-018-1818-9. Epub 2018 Sep 3. PMID: 30178226.
12. Bittner R, Bain K, Bansal VK, Berrevoet F, Bingener-Casey J, Chen D, Chen J, Chowbey P, Dietz UA, de Beaux A, Ferzli G, Fortelny R, Hoffmann H, Iskander M, Ji Z, Jorgensen LN, Khullar R, Kirchhoff P, Köckerling F, Kukleta J, LeBlanc K, Li J, Lomanto D, Mayer F, Meytes V, Misra M, Morales-Conde S, Niebuhr H, Radvinsky D, Ramshaw B, Ranev D, Reinpold W, Sharma A, Schrittwieser R, Stechemesser B, Sutedja B, Tang J, Warren J, Weyhe D, Wiegering A, Woeste G, Yao Q. Update of Guidelines for laparoscopic treatment of ventral and incisional abdominal wall hernias (International Endohernia Society (IEHS))-Part A. Surg Endosc. 2019 Oct;33(10):3069-3139. doi: 10.1007/s00464-019-06907-7. Epub 2019 Jun 27. Erratum in: Surg Endosc. 2019 Oct;33(10):3140-3142. doi: 10.1007/s00464-019-06977-7. PMID: 31250243; PMCID: PMC6722153.
13. Köckerling F, Sheen AJ, Berrevoet F, Campanelli G, Cuccurullo D, Fortelny R, Friis-Andersen H, Gillion JF, Gorjanc J, Kopelman D, Lopez-Cano M, Morales-Conde S, Österberg J, Reinpold W, Simmermacher RKJ, Smietanski M, Weyhe D, Simons MP. The reality of general surgery training and increased complexity of abdominal wall hernia surgery. Hernia. 2019 Dec;23(6):1081-1091. doi: 10.1007/s10029-019-02062-z. Epub 2019 Nov 21. PMID: 31754953; PMCID: PMC6938469.
14. Cobb WS. A Current Review of Synthetic Meshes in Abdominal Wall Reconstruction. Plast Reconstr Surg. 2018 Sep;142(3 Suppl):64S-71S. doi: 10.1097/PRS.0000000000004857. PMID: 30138270.
15. Köckerling F, Alam NN, Antoniou SA, Daniels IR, Famiglietti F, Fortelny RH, Heiss MM, Kallinowski F, Kyle-Leinhase I, Mayer F, Miserez M, Montgomery A, Morales-Conde S, Muysoms F, Narang SK, Petter-Puchner A, Reinpold W, Scheuerlein H, Smietanski M, Stechemesser B, Strey C, Woeste G, Smart NJ. What is the evidence for the use of biologic or biosynthetic meshes in abdominal wall reconstruction? Hernia. 2018 Apr;22(2):249-269. doi: 10.1007/s10029-018-1735-y. Epub 2018 Jan 31. PMID: 29388080; PMCID: PMC5978919.
16. Grove TN, Kontovounisios C, Montgomery A, Heniford BT, Windsor ACJ, Warren OJ; AWR Europe Collaborative. Perioperative optimization in complex abdominal wall hernias: Delphi consensus statement. BJS Open. 2021 Sep 6;5(5):zrab082. doi:

DOI: 10.69605/ijlbpr_14.3.2025.234

10.1093/bjsopen/zrab082. PMID: 34568888; PMCID: PMC8473840.

17. Kao AM, Arnold MR, Augenstein VA, Heniford BT. Prevention and Treatment Strategies for Mesh Infection in Abdominal Wall Reconstruction. Plast Reconstr Surg. 2018 Sep;142(3 Suppl):149S-155S. doi: 10.1097/PRS.0000000000004871. PMID: 30138283.
18. Ayuso SA, Elhage SA, Zhang Y, Aladegbami BG, Gersin KS, Fischer JP, Augenstein VA, Colavita PD, Heniford BT. Predicting rare outcomes in abdominal wall reconstruction using image-based deep learning models. Surgery. 2023 Mar;173(3):748-755. doi: 10.1016/j.surg.2022.06.048. Epub 2022 Oct 11. PMID: 36229252.
19. Elhage SA, Ayuso SA, Deerenberg EB, Shao JM, Prasad T, Kercher KW, Colavita PD, Augenstein VA, Todd Heniford B. Factors Predicting Increased Length of Stay in Abdominal Wall Reconstruction. Am Surg. 2023 May;89(5):1539-1545. doi: 10.1177/00031348211047503. Epub 2021 Dec 29. PMID: 34965157.
20. Deerenberg EB, Elhage SA, Raible RJ, Shao JM, Augenstein VA, Heniford BT, Lopez R. Image-guided botulinum toxin injection in the lateral abdominal wall prior to abdominal wall reconstruction surgery: review of techniques and results. Skeletal Radiol. 2021 Jan;50(1):1-7. doi: 10.1007/s00256-020-03533-6. Epub 2020 Jul 4. PMID: 32621063.