

A COMPARATIVE STUDY BETWEEN LAPAROSCOPIC AND OPEN CONVENTIONAL REPAIR OF UMBILICAL AND PARAUMBILICAL HERNIAS FOR DEFECTS LESS THAN 2 CMS

Aysha Sanjeetha S¹, A. Akmal², Sampathkumar Poral³

¹Postgraduate, Department of Surgery, AVMC, Puducherry, India.

²Associate Professor, Department of Surgery, AVMC, Puducherry, India.

³Professor and HOD, Department of Surgery, AVMC, Puducherry, India.

Received : 14/01/2026
Received in revised form : 01/04/2026
Accepted : 18/04/2026

Keywords:

Umbilical hernia, Paraumbilical hernia, Laparoscopic repair, Open hernia repair, Postoperative outcomes, Quality of life..

Corresponding Author:

Dr. Aysha Sanjeetha S,
Email: snjeetha@gmail.com

DOI: 10.47009/jamp.2026.8.2.181

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (2); 992-997



ABSTRACT

Background: Umbilical and paraumbilical hernias with small defects (<2 cm) are common, and the optimal choice between laparoscopic and conventional open repair remains debated with respect to recovery, wound morbidity, recurrence, and patient-reported outcomes. The objective is to compare the outcomes of laparoscopic repair versus conventional open repair for umbilical and paraumbilical hernias with defect sizes <2 cm. **Materials and Methods:** This single-centre, hospital-based prospective comparative study was conducted at Aarupadai Veedu Medical College and Hospital, Puducherry (March 2024–September 2025), enrolling 60 adults (>18 years) with primary umbilical/paraumbilical hernia defects <2 cm undergoing elective repair. Participants underwent laparoscopic repair (Group A, n=30) or conventional open primary repair (Group B, n=30), and outcomes were compared using SPSS v27. **Results:** Baseline characteristics were comparable between groups. Postoperative recovery favoured Group A with earlier bowel sounds (1.2±0.4 vs 1.7±0.7 days; p=0.002), earlier oral feeds (1.1±0.3 vs 1.8±0.6 days; p<0.001), and shorter RTNA (7.8±1.9 vs 11.1±2.9 days; p<0.001). Early pain scores were lower in Group A (POD0 5.8 vs 6.7; POD2 2.9 vs 4.1; p≤0.001), overall complications were reduced (20.0% vs 46.7%; p=0.034), and wound infection was less frequent (3.3% vs 20.0%; p=0.003) with fewer antibiotic days (3.3±1.4 vs 5.8±2.6; p<0.001). Hospital stay was shorter in Group A (2.7±0.6 vs 3.9±1.1 days; p<0.001), while cost differences were not significant; recurrence was low in both groups, and EurHS-QoL and CCS scores were significantly better in Group A. **Conclusion:** Laparoscopic repair for small (<2 cm) umbilical and paraumbilical hernias was associated with faster recovery, lower early pain and wound morbidity, shorter hospital stay, and better hernia-specific quality-of-life outcomes than conventional open repair, with similarly low recurrence rates.

INTRODUCTION

Umbilical and paraumbilical hernias are common anterior abdominal wall defects in adults and represent an important cause of outpatient surgical consultations and elective operations.^[1] They occur through weakness at or adjacent to the umbilical ring and may present with a visible bulge, discomfort, activity limitation, or complications such as incarceration and strangulation, which can necessitate urgent intervention. Although exact population incidence varies across reports (10 to 25%), umbilical hernias constitute a substantial proportion of ventral hernias,^[2] they are also associated with recognised risk factors such as obesity, multiparity/pregnancy-related stretching,

chronic cough, constipation, and conditions causing raised intra-abdominal pressure.^[3-5]

The optimal repair strategy for small primary umbilical and paraumbilical hernias remains debated, particularly for defects below 2 cm where surgeons may choose between suture closure, open mesh reinforcement (commonly preperitoneal), or minimally invasive mesh placement. The 2020 guidance jointly produced by the European Hernia Society and the Americas Hernia Society emphasised the need to tailor technique to defect size and patient factors, while acknowledging important evidence gaps for the smallest defects and for comparing approaches across diverse patient populations.^[6] In corroboration, Köckerling et al. (2021) a Hernia-based analysis of small (<2 cm) umbilical hernias showed that suture repair continues to be widely used

and that outcomes such as recurrence and pain can be influenced by technique choice and patient characteristics, supporting the need for context-specific evidence to guide selection.^[7] Comparative literature suggests potential trade-offs between laparoscopic and open conventional repair. Gonzalez et al. (2003) reported advantages of laparoscopic repair in terms of recurrence and recovery, albeit with differences in hernia size and mesh use between groups.^[8] Lau & Patil (2003) and Othman et al. (2012) have demonstrated that laparoscopic approaches may reduce early postoperative pain and wound morbidity versus some open techniques, while sometimes requiring longer operative time.^[9,10] NSQIP analyses have shown lower odds of wound complications with laparoscopic repair but longer operative time and slightly longer length of stay, while nationwide data have reported differing short-term infection and reoperation profiles between open and laparoscopic mesh repairs.^[11,12] Importantly, when attention is restricted to small paraumbilical defects (≤ 2 cm), single-centre data from Chung et al. (2019) suggest that open repair can be faster and facilitate early discharge, with broadly comparable early complication and recurrence rates, implying that the best approach may depend on patient selection and local resource considerations.^[13] Because small hernia repairs aim to restore function with minimal morbidity, rigorous assessment should extend beyond recurrence to include postoperative pain trajectories, return to usual activities, wound-related events, and longer-term mesh-related symptoms. Against this background, the objective of the present study was to compare the outcomes of laparoscopic repair versus conventional open repair for umbilical and paraumbilical hernias with defect sizes < 2 cm.

MATERIALS AND METHODS

This was a single-centre, hospital-based, prospective, comparative study conducted in the Department of General Surgery, Aarupadai Veedu Medical College and Hospital, Puducherry, India for a duration of 18 months (March 2024 to September 2025). The study was approved by the Institutional Human Ethics Committee (IHEC) with reference number AV/IHEC/01/2024/059 dated 07/06/2024. The participants were given the Participant Information Sheet (PIS) in their native language, and its contents were verbally explained to ensure their understanding and satisfaction. Adults aged > 18 years of either sex who presented with an umbilical or paraumbilical hernia with a defect size < 2 cm were included, provided they were willing to participate and gave written informed consent. Patients aged < 18 years, those with a defect size > 2 cm, and those with coagulopathy, severe cardiopulmonary disease, ascites, immunocompromised states (including chronic immunosuppression), chronic

immunotherapy or steroid use, or renal failure were excluded.

The sample size was calculated based on comparing two independent proportions, using expected postoperative complication rates from Abhinava et al. (6.1% in the laparoscopic group and 35.9% in the open group).^[14] With a two-sided α of 0.05 and 80% power, the required sample size was 30 participants per group, resulting in a total sample size of 60. Participants were recruited using a nonprobability sampling approach, employing purposive sampling with consecutive enumeration. After enrolment, relevant baseline data were collected, including demographic details (age and sex), detailed clinical history, findings on clinical examination, and the size of the hernia defect. Routine preoperative investigations were documented. Participants were then divided into two groups based on the type of repair performed. Group A comprised patients who underwent laparoscopic repair, whereas Group B comprised patients who underwent conventional primary open repair.

Postoperatively, participants were followed throughout their hospital stay. Data were collected on key perioperative and postoperative outcomes, including the duration of hospital stay and the postoperative day of discharge. Return to Normal Activity (RTNA) was documented and was assessed using objective postoperative milestones such as the postoperative day of return of bowel sounds and the postoperative day of starting oral feeds. Pain was assessed using the 0–10 Numeric Pain Rating Scale. Participants were monitored for postoperative infections and other complications. Wound infections were documented, and the number of days of antibiotic usage was recorded. Other postoperative events, including sensory disturbances and bladder/bowel disturbances, were elicited and recorded. Participants were also observed for immediate recurrence. Quality-of-life scoring was performed using the European Hernia Society questionnaire (EuraHS-QoL) and the Carolina Comfort Scale to enable objective comparison of outcomes between the laparoscopic and open repair groups.

Statistical Analysis: Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarised as mean \pm standard deviation (SD) when approximately normally distributed and as median (interquartile range, IQR) when skewed. Categorical variables were expressed as frequency and percentage. Normality of continuous data was assessed using graphical methods (histograms and Q–Q plots) and the Shapiro–Wilk test. Between-group comparisons (Group A vs Group B) for continuous outcomes were performed using the independent-samples t-test for normally distributed data; for non-normally distributed data, the Mann–Whitney U test was applied. Categorical variables were compared using the Chi-square test, and when expected cell counts

were <5, the Fisher's exact test was used. All hypothesis tests were two-tailed, and a p value <0.05 was considered statistically significant.

RESULTS

Both groups were comparable at baseline, with similar mean age (45.3 ± 8.8 vs 48.1 ± 8.7 years; p=0.231), sex distribution (males 63.3% vs 60.0%; p=1.000), diagnosis profile (paraumbilical hernia 53.3% vs 56.7%; p=1.000), and mean defect size (1.3 ± 0.4 cm in both; p=0.972). Postoperatively, Group A showed faster recovery, with earlier return of bowel sounds (1.2 ± 0.4 vs 1.7 ± 0.7 days; p=0.002) and earlier initiation of oral feeds (1.1 ± 0.3 vs 1.8 ± 0.6 days; p<0.001), resulting in a significantly shorter overall RTNA time (7.8 ± 1.9 vs 11.1 ± 2.9 days; p<0.001). Postoperative pain scores were consistently lower in Group A than Group B during the early postoperative period, with significant differences on POD0 (5.8 ± 1.0 vs 6.7 ± 1.0; p=0.001), POD1 (4.6 ± 1.3 vs 5.7 ± 1.3; p=0.001), POD2 (2.9 ± 1.1 vs 4.1 ± 1.1; p<0.001), and POD3 (2.5 ± 1.1 vs 3.3 ± 1.1; p=0.010). By discharge, pain scores remained lower in Group A (1.5 ± 1.1 vs 2.0 ± 1.1), although the difference was not statistically significant (p = 0.082).

Overall postoperative complications were significantly less frequent in Group A than in Group

B (20.0% vs 46.7%; p=0.034). Individual complications were numerically lower in Group A, including sensory disturbances (6.7% vs 16.7%), seroma (6.7% vs 20.0%), and urinary retention (3.3% vs 10.0%), but none of these differences reached statistical significance (all p>0.05); other events such as haematoma, ileus/delayed bowel activity, and postoperative fever were uncommon in both groups. Group A had significantly lower wound infection rates than Group B (3.3% vs 20.0%; p=0.003), required fewer antibiotic days (3.3 ± 1.4 vs 5.8 ± 2.6; p<0.001), and had a shorter hospital stay (2.7 ± 0.6 vs 3.9 ± 1.1 days; p<0.001). Total in-hospital cost was comparable between groups (mean □52,356.7 vs □43,860.0; p=0.302; median □51,600 vs □43,300; p=0.154). Recurrence was infrequent and did not differ significantly (follow-up recurrence: 3.3% vs 10.0%; p=0.612). Quality-of-life outcomes favoured Group A, with lower EuraHS-QoL pain (5.5 ± 2.0 vs 7.5 ± 2.3), activity restriction (4.6 ± 2.1 vs 7.2 ± 3.0), cosmetic discomfort (4.2 ± 2.6 vs 6.4 ± 2.9), and total scores (14.3 ± 4.0 vs 21.1 ± 4.9), all significant (p ≤ 0.003). Similarly, Carolina Comfort Scale scores were significantly better in Group A, with lower mesh sensation (5.9 ± 3.9 vs 11.6 ± 4.6), pain (4.3 ± 3.0 vs 7.8 ± 3.3), movement limitation (3.6 ± 2.5 vs 8.4 ± 2.8), and total CCS (13.7 ± 5.7 vs 27.9 ± 6.8), all p < 0.001.

Table 1: Comparison of Baseline Characteristics and Return to Normal Activity (RTNA) Outcomes Between Group A and Group B

	Group A (n = 30)	Group B (n= 30)	P value	
Age (years), Mean ± SD	45.3 ± 8.8	48.1 ± 8.7	0.231	
Sex, n (%)	Male	19 (63.3)	18 (60.0)	1.000
	Female	11 (36.7)	12 (40.0)	
Diagnosis, n (%)	Umbilical	14 (46.7)	13 (43.3)	1.000
	Paraumbilical	16 (53.3)	17 (56.7)	
Defect size (cm), Mean ± SD	1.3 ± 0.4	1.3 ± 0.4	0.972	
Defect size	≤1.0 cm	8 (26.7)	7 (23.3)	0.952
	1.1–1.5 cm	15 (50.0)	16 (53.3)	
	1.6–2.0 cm	7 (23.3)	7 (23.3)	
Postoperative day of return of bowel sounds, Mean ± SD	1.2 ± 0.4	1.7 ± 0.7	0.002*	
Postoperative day of starting oral feeds, Mean ± SD	1.1 ± 0.3	1.8 ± 0.6	<0.001*	
Overall RTNA time (days), Mean ± SD	7.8 ± 1.9	11.1 ± 2.9	<0.001*	

*Statistically significant at p<0.05

Table 2: Comparison of Postoperative Complications Between Group A and Group B

Complication	Group A (n =30)	Group B (n =30)	P value
Any complication, n (%)	6 (20.0)	14 (46.7)	0.034*
Sensory disturbances, n (%)	2 (6.7)	5 (16.7)	0.424
Bladder / bowel disturbances, n (%)	2 (6.7)	4 (13.3)	0.671
Seroma, n (%)	2 (6.7)	6 (20.0)	0.254
Hematoma, n (%)	1 (3.3)	2 (6.7)	1.000
Urinary retention, n (%)	1 (3.3)	3 (10.0)	0.612
Ileus/delayed bowel activity, n (%)	1 (3.3)	2 (6.7)	1.000
Postoperative fever, n (%)	1 (3.3)	2 (6.7)	1.000

*Statistically significant at p<0.05

Table 3: Comparison of Wound Outcomes, Hospital Stay, Cost, Recurrence, and Quality-of-Life Scores Between Group A and Group B

	Group A (n=30)	Group B (n=30)	P value
Wound infection, antibiotic usage and hospital stay			
Wound infection, n (%)	1 (3.3)	6 (20.0)	0.003*
Antibiotic days, Mean ± SD	3.3 ± 1.4	5.8 ± 2.6	<0.001*
Duration of hospital stay (days), Mean ± SD	2.7 ± 0.6	3.9 ± 1.1	<0.001*

Cost analysis during hospital stay			
Total cost during hospital stay, Mean ± SD (□)	52356.7 ± 12556.2	43860.0 ± 11291.6	0.302
Total cost during hospital stay, Median (IQR) (□)	51600 (45400–59650)	43300 (34075–50500)	0.154
Recurrence outcomes			
Immediate recurrence, n (%)	0 (0.0)	1 (3.3)	1.000
Recurrence on follow-up, n (%)	1 (3.3)	3 (10.0)	0.612
Time to recurrence among those with follow-up recurrence (months), Median (IQR)	5.1 (5.1–5.1)	8.0 (7.4–8.7)	0.667
Quality of life (EuraHS-QoL)			
Pain domain score, Mean ± SD	5.5 ± 2.0	7.5 ± 2.3	<0.001*
Activity restriction domain score, Mean ± SD	4.6 ± 2.1	7.2 ± 3.0	<0.001*
Cosmetic discomfort domain score, Mean ± SD	4.2 ± 2.6	6.4 ± 2.9	0.003*
Total EuraHS-QoL score, Mean ± SD	14.3 ± 4.0	21.1 ± 4.9	<0.001*
Carolina Comfort Scale			
Mesh sensation score, Mean ± SD	5.9 ± 3.9	11.6 ± 4.6	<0.001*
Pain score, Mean ± SD	4.3 ± 3.0	7.8 ± 3.3	<0.001*
Movement limitation score, Mean ± SD	3.6 ± 2.5	8.4 ± 2.8	<0.001*
Total CCS score, Mean ± SD	13.7 ± 5.7	27.9 ± 6.8	<0.001*

*Statistically significant at p<0.05

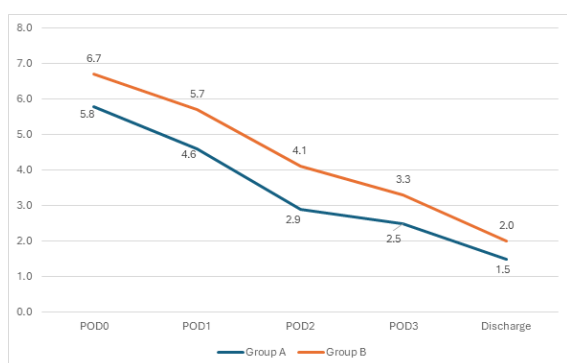


Figure 1: Postoperative Pain Scores (VAS) Over Time in Group A and Group B

DISCUSSION

The present comparison of laparoscopic repair (Group A) versus conventional open repair (Group B) for small umbilical/paraumbilical hernias (<2 cm) demonstrated broadly comparable baseline profiles (age, sex, and diagnosis distribution) and similar mean defect size, indicating that early postoperative differences were unlikely to be driven by preoperative imbalance. These findings are important because Hilling et al. (2009) and Losu et al. (2023) noted that the outcomes in small primary midline hernias are strongly influenced by operative access trauma, wound burden, and perioperative care pathways rather than by major anatomical heterogeneity when defect size is controlled.^[15,16] A consistent and clinically meaningful advantage of laparoscopy in this dataset was faster functional recovery. Group A achieved earlier return of bowel sounds and earlier resumption of oral feeds, translating into a shorter overall ‘return to normal activity’ interval. Mechanistically, minimally invasive access generally reduces abdominal wall tissue trauma and inflammatory response, and it can facilitate earlier mobilisation and feeding protocols when pain and ileus are less pronounced, as noted by Hatewar et al. (2024).^[17] In Antic et al. (2022) and Gonzalez et al. (2003), laparoscopy has repeatedly been associated with faster convalescence and earlier return to normal activity compared with open mesh

repairs, despite sometimes longer operative times.”^[8,18]

“Early postoperative pain trajectories in this study also favoured laparoscopy (significantly lower pain scores from POD0 to POD3, with convergence by discharge). This pattern aligns with Chung et al. (2019) and Othman et al. (2012); the early pain benefit of laparoscopy is often driven by avoidance of larger incisions and reduced soft tissue dissection, while later pain differences may narrow as wound healing progresses.^[10,13] A randomised prospective comparison of laparoscopic versus open paraumbilical repair reported markedly lower early postoperative pain after laparoscopy (at 6 hours) with similar short-stay patterns, supporting the plausibility of the early analgesic advantage observed here.^[10]

The wound-related outcomes in the present results are particularly notable; Group A had substantially fewer wound infections and fewer antibiotic days. This direction of effect is consistent with Assakran et al. (2024), Miguel et al. (1998) and Zhang et al. (2022) showing a lower wound-complication signal for laparoscopic umbilical hernia repair after risk adjustment, even when overall short-term morbidity is similar.^[19-21] For example, NSQIP-based analyses have demonstrated reduced wound complications with laparoscopy (while also noting trade-offs such as longer operative time).^[11] Beyond surgical site infection alone, the overall complication rate was lower in Group A, whereas individual low-frequency events (seroma, haematoma, urinary retention, ileus, and postoperative fever) did not differ significantly – an expected pattern in modest sample sizes where composite morbidity captures the cumulative burden better than any single rare endpoint. Antic et al. (2022) and Muysoms et al. (2016) evaluating open versus laparoscopic mesh repair for primary umbilical/epigastric hernias, have similarly reported higher superficial SSI-related readmissions and higher early reoperation for complications after open repair.^[18,22]

Hospital stay outcomes in the present dataset (shorter LOS and earlier postoperative discharge in Group A) track logically with less early pain, earlier feeding,

and lower wound morbidity. However, the literature is heterogeneous for very small defects; Cassie et al. (2014), Chung et al. (2019) and Shaikh et al. (2013) have reported shorter operative times and even shorter LOS with open repair compared with laparoscopy, likely reflecting day-case protocols for simple open suture repair and the selection of laparoscopic repair for different patient subsets and anaesthetic pathways.^[11,13,23] In a defect-limited cohort (≤ 2 cm), open repair had shorter operative time and shorter LOS, with similar early complication rates and low recurrence overall – illustrating that perioperative pathway design (day surgery vs inpatient) can materially influence LOS comparisons across centres.^[7]

Recurrence was infrequent in both groups in the present results and did not differ statistically, which is plausible given the small defects and limited recurrence events. Cassie et al. (2014), Muysoms et al. (2012) and Parseliunas et al. (2022) suggest that technique choice in small umbilical hernias is nuanced; suture repair remains common for <2 cm defects in real-world practice, but it has been associated with higher recurrence compared with open mesh repair in multivariable analyses, while laparoscopic IPOM may show a mixed profile – often favourable for some short-term outcomes but with concerns about pain and certain complication domains in small hernias.^[11,24,25]

The health-related quality-of-life findings (better EuraHS-QoL and Carolina Comfort Scale scores in Group A) integrate well with the observed reductions in early pain, wound infection, and activity restriction. Hernia-specific PROMs are designed to capture domains that generic tools may miss – such as mesh sensation, movement limitation, and cosmetic discomfort – and CCS has been widely used as a mesh- and comfort-focused instrument after abdominal wall hernia repair, as noted by Grove et al. (2021), Nielsen et al. (2014) and van Veenendaal et al. (2021).^[26-28] The EuraHS-QoL framework similarly operationalises pain, activity restriction, and cosmetic discomfort as key patient-prioritised outcomes, making it a suitable anchor for interpreting why functional recovery benefits translate into superior patient-reported comfort and restrictions in the early recovery window, in corroboration with Sanderson et al. (2024).^[29] Finally, the cost signal in this dataset (numerically higher in-hospital cost in Group A without statistical significance) is directionally consistent with Kayondo et al. (2025) and Netto et al. (2014) where laparoscopy entails higher direct theatre/equipment costs (ports, fixation devices, and specialised meshes) while potentially reducing downstream costs through fewer wound complications and earlier return to productivity.^[30,31] The absence of statistical significance here may reflect sample size and within-group cost variability, and it also highlights that ‘total cost’ is highly sensitive to what is counted (direct hospital charges vs societal costs, readmissions, wound care costs, and time off work). In practice, the interpretation is that

laparoscopy may shift the cost structure: potentially higher upfront procedural costs but lower wound-morbidity burden and faster functional recovery. This study had certain limitations that should be considered while interpreting the findings. Being a single-centre, hospital-based study with a relatively small sample size (30 participants per group), the power to detect differences in low-frequency outcomes such as individual complications and recurrence was limited, and subgroup analyses were not feasible. Allocation to laparoscopic versus open repair was based on the procedure performed rather than randomisation, which may have introduced selection bias despite baseline comparability, and outcomes could also have been influenced by surgeon preference, experience (learning curve), and variations in perioperative practices. Several outcomes (return to normal activity milestones, pain scores, and quality-of-life measures) involved patient-reported assessments and could be subject to reporting bias. Finally, the cost analysis was limited to in-hospital costs and did not account for indirect costs such as loss of wages, travel, or costs related to late complications or readmissions, which may affect overall cost-effectiveness comparisons.

CONCLUSION

In this single-centre prospective comparative study of small (<2 cm) umbilical and paraumbilical hernias, laparoscopic repair demonstrated superior short-term recovery compared with conventional open repair. Patients in the laparoscopic group achieved earlier return of bowel sounds and oral feeds, had a significantly shorter time to return to normal activity, experienced lower early postoperative pain, and showed reduced overall postoperative complications, particularly wound infection, with fewer antibiotic days. These advantages translated into shorter hospital stays and better patient-reported outcomes, with significantly improved EuraHS-QoL and Carolina Comfort Scale scores. Recurrence rates were low and comparable between groups, while in-hospital costs were numerically higher with laparoscopy but not significantly different.” Overall, the findings suggest that laparoscopic repair can offer meaningful benefits in early recovery, wound morbidity, and quality of life for defects <2 cm, supporting its use as a preferred approach in appropriately selected patients where expertise and resources are available.

REFERENCES

1. Huerta S, McAllister J, Phung C, Guzzetta AA. Elective Umbilical Hernia Repair in Adults in the 21st Century: Challenging the Status Quo. *Journal of Clinical Medicine* [Internet]. 2025; 14(17):[6324 p.].
2. Maia RA, Salgaonkar HP, Lomanto D, Loo L. Umbilical hernia: when and how. *Annals of Laparoscopic and Endoscopic Surgery*. 2019;4.
3. Kulacoglu H. Umbilical Hernia Repair and Pregnancy: Before, during, after.... *Front Surg*. 2018;5:1.

4. AhmedAlenazi A, Alsharif MM, Hussain MA, Alenezi NG, Alenazi AA, Almadani SA, et al. Prevalence, risk factors and character of abdominal hernia in Arar City, Northern Saudi Arabia in 2017. *Electron Physician*. 2017;9(7):4806-11.
5. Zelicha H, Bell DS, Chen D, Chen Y, Livingston EH. Obesity and abdominal hernia in ambulatory patients, 2018-2023. *Hernia*. 2024;28(4):1317-24.
6. Henriksen N, Montgomery A, Kaufmann R, Berrevoet F, East B, Fischer J, et al. Guidelines for treatment of umbilical and epigastric hernias from the European Hernia Society and Americas Hernia Society. *Journal of British Surgery*. 2020;107(3):171-90.
7. Köckerling F, Brunner W, Mayer F, Fortelny R, Adolf D, Niebuhr H, et al. Assessment of potential influencing factors on the outcome in small (<2 cm) umbilical hernia repair: a registry-based multivariable analysis of 31,965 patients. *Hernia*. 2021;25(3):587-603.
8. Gonzalez R, Mason E, Duncan T, Wilson R, Ramshaw BJ. Laparoscopic versus open umbilical hernia repair. *Jcls*. 2003;7(4):323-8.
9. Lau H, Patil N. Umbilical hernia in adults. *Surgical Endoscopy and Other Interventional Techniques*. 2003; 17:2016-20.
10. Othman IH, Metwally YH, Bakr IS, Amer YA, Gaber MB, Elgohary SA. Comparative study between laparoscopic and open repair of paraumbilical hernia. *J Egypt Soc Parasitol*. 2012;42(1):175-82.
11. Cassie S, Okrainec A, Saleh F, Queresy FS, Jackson TD. Laparoscopic versus open elective repair of primary umbilical hernias: short-term outcomes from the American College of Surgeons National Surgery Quality Improvement Program. *Surg Endosc*. 2014;28(3):741-6.
12. Henriksen NA, Jorgensen LN, Friis-Andersen H, Helgstrand F. Open versus laparoscopic umbilical and epigastric hernia repair: nationwide data on short- and long-term outcomes. *Surg Endosc*. 2022;36(1):526-32.
13. Chung I, Cheung BH, Law TT, Ng KK, Ng L, Wong KY. Laparoscopic versus open repair for small paraumbilical hernia: A retrospective review. *Asian J Endosc Surg*. 2019;12(3):306-10.
14. Abhinava D, Shashidhara N, Seshagiri R, Santhosh C, Mallikarjuna N, Niranjana N. A clinical study of laparoscopic versus open umbilical hernia repair. *Surgical Update: Int J surg Orthopaedics*. 2017;3(4):157-61.
15. Hilling DE, Koppert LB, Keijzer R, Stassen LP, Oei IH. Laparoscopic correction of umbilical hernias using a transabdominal preperitoneal approach: results of a pilot study. *Surg Endosc*. 2009;23(8):1740-4.
16. Losu PU, Lal R, Gupta AK, Chaudhary P. Assessment of quality of life using EuraHS-QoL score and postoperative outcome measures following endoscopic video-assisted component separation with laparoscopic intraperitoneal onlay mesh repair in large midline ventral hernia repair. *International Journal of Abdominal Wall and Hernia Surgery*. 2023;6(4).
17. Hatewar A, Mahakalkar C, Kshirsagar S, Ram Sohan P, Dixit S, Bikkumalla S. From Meshes to Minimally Invasive Techniques: A Comprehensive Review of Modern Hernia Repair Approaches. *Cureus*. 2024;16(8):e66206.
18. Antic A, Kmezc S, Nikolic V, Radenkovic D, Markovic V, Pejovic I, et al. Quality of life following two different techniques of an open ventral hernia repair for large hernias: a prospective randomized study. *BMC Surg*. 2022;22(1):99.
19. Miguel PR, Reusch M, daRosa AL, Carlos JR. Laparoscopic hernia repair--complications. *Jcls*. 1998;2(1):35-40.
20. Zhang Z, Li L, Liu B, Wang F, Wang W, Liu X, et al. Effect of Laparoscopic Total Extraperitoneal Umbilical Hernia Repair on Incision Infection, Complication Rate, and Recurrence Rate in Patients with Umbilical Hernia. *J Healthc Eng*. 2022; 2022:7055045.
21. Assakran BS, Al-Harbi AM, Abdulrahman Albadrani H, Al-Dohaiman RS. Risk Factors for Postoperative Complications in Hernia Repair. *Cureus*. 2024;16(1):e51982.
22. Muysoms FE, Vanlander A, Ceulemans R, Kyle-Leinhase I, Michiels M, Jacobs I, et al. A prospective, multicenter, observational study on quality of life after laparoscopic inguinal hernia repair with ProGrip laparoscopic, self-fixating mesh according to the European Registry for Abdominal Wall Hernias Quality of Life Instrument. *Surgery*. 2016;160(5):1344-57.
23. Shaikh I, Willder JM, Kumar S. Same day discharge, surgical training and early complications after open and laparoscopic repair of primary paraumbilical hernia. *Hernia*. 2013;17(4):505-9.
24. Parseliunas A, Paskauskas S, Simatoniene V, Vaitekunas J, Venskutonis D. Adaptation and validation of the Carolinas Comfort Scale: a questionnaire-based cross-sectional study. *Hernia*. 2022;26(3):735-44.
25. Muysoms F, Campanelli G, Champault GG, DeBeaux AC, Dietz UA, Jeekel J, et al. EuraHS: the development of an international online platform for registration and outcome measurement of ventral abdominal wall hernia repair. *Hernia*. 2012;16(3):239-50.
26. Nielsen K, Poelman MM, den Bakker FM, van der Ploeg T, Bonjer HJ, Schreurs WH. Comparison of the Dutch and English versions of the Carolinas Comfort Scale: a specific quality-of-life questionnaire for abdominal hernia repairs with mesh. *Hernia*. 2014;18(4):459-64.
27. Grove TN, Muirhead LJ, Parker SG, Brogden DRL, Mills SC, Kontovounisios C, et al. Measuring quality of life in patients with abdominal wall hernias: a systematic review of available tools. *Hernia*. 2021;25(2):491-500.
28. van Veenendaal N, Poelman MM, van den Heuvel B, Dwars BJ, Schreurs WH, Stoot J, et al. Patient-reported outcomes after incisional hernia repair. *Hernia*. 2021;25(6):1677-84.
29. Sanderson R, DD DE-M, Cesário JCB, Sanderson LGD, Zilberstein B. QUALITY OF LIFE USING EURAHS-QoL SCORES AFTER SURGICAL TREATMENT OF INGUINAL HERNIA: LAPAROSCOPIC TRANSABDOMINAL PREPERITONEAL (TAPP) AND LICHTENSTEIN TECHNIQUES. *Arq Bras Cir Dig*. 2024;37:e1798.
30. Spencer Netto F, Queresy F, Camilotti BG, Pitzul K, Kwong J, Jackson T, et al. Hospital costs associated with laparoscopic and open inguinal herniorrhaphy. *Jcls*. 2014;18(4).
31. Kayondo K, Nyundo M, Gasakure M, Mutumuliza J, Ngeruka L, Hitimana R, et al. Cost comparison of laparoscopic versus open surgery for common procedures in Rwandan teaching hospitals. *Surg Open Sci*. 2025;27:81-7.