ORIGINAL RESEARCH

A Comparative Study on Single-Incision Laparoscopic Surgery vs. Conventional Multi-Port Laparoscopy in Hernia Repair

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ABSTRACT

Aim: This study aimed to compare single-incision laparoscopic surgery (SILS) and conventional multi-port laparoscopy (MPL) in hernia repair, focusing on operative outcomes, postoperative pain, recovery, complications, and cosmetic results. **Material and Methods:** This prospective, comparative study was conducted at a tertiary care center, including 150 patients with hernias who were randomized into two groups: SILS (n = 75) and MPL (n = 75). Key outcomes included operative time, postoperative pain (assessed using a Visual Analog Scale at 6, 12, and 24 hours), hospital stay, recovery time, complications, and cosmetic satisfaction. Statistical analysis was performed using Student's t-test and Chi-square test, with a significance level of $p < 0.05$. **Results:** The mean operative time was longer in the SILS group (52.46 ± 8.21 minutes) compared to the MPL group (47.28 ± 7.89 minutes, p = 0.001). Postoperative pain was significantly lower in the SILS group at all time points, with a mean VAS score of 3.54 ± 1.02 vs. 4.26 ± 1.14 at 6 hours (p = 0.001). The SILS group had a shorter hospital stay (1.84 ± 0.57 days vs. 2.24 ± 0.62 days, p = 0.001) and faster recovery (10.32 ± 2.16 days vs. 12.84 ± 2.47 days, p = 0.001). Complication rates were low and comparable between groups, while cosmetic satisfaction was higher in the SILS group (93.33% vs. 84.00%, p = 0.045). **Conclusion:** SILS offers advantages over MPL, including reduced postoperative pain, faster recovery, and superior cosmetic outcomes, although it requires slightly longer operative times. Both techniques showed comparable safety and complication rates. SILS is a viable option for patients prioritizing minimal scarring and quicker recovery, provided the surgeon has adequate expertise.

Keywords: Single-incision laparoscopic surgery, Multi-port laparoscopy, Hernia repair, Postoperative outcomes, Cosmetic satisfaction

INTRODUCTION

Hernia repair is among the most common surgical procedures performed globally, addressing the protrusion of abdominal contents through a weakened area in the abdominal wall. Laparoscopic surgery has revolutionized the treatment of hernias, offering minimally invasive techniques that minimize tissue trauma, reduce postoperative pain, and promote faster recovery. Within laparoscopic techniques, two major approaches have gained prominence: single-incision laparoscopic surgery (SILS) and conventional multi-port laparoscopy (MPL). Each technique has its own set of advantages, limitations, and applications, necessitating a comparative analysis to determine their respective roles in hernia repair.[1]Conventional MPL has been the gold standard in laparoscopic hernia repair for decades. The technique utilizes three to four ports, allowing for excellent visualization, triangulation of instruments, and precise dissection. This approach has demonstrated high success rates, low recurrence rates, and manageable complication profiles, making it the benchmark for minimally invasive hernia repair. Despite its success, MPL involves multiple incisions, which can leave visible scars, increase postoperative pain, and potentially lengthen recovery time.[2] SILS emerged as an innovative alternative to MPL, aiming to enhance the minimally invasive nature of laparoscopic surgery. SILS involves a single incision, typically made at the umbilicus, through which a specialized port accommodates multiple instruments. This technique eliminates the need for multiple incisions, offering superior cosmetic results and potentially reducing postoperative pain. The single incision also aligns with patients' growing preference for minimally invasive procedures with better aesthetic outcomes.

However, SILS is technically more demanding due to limited instrument maneuverability and reduced spatial separation of the surgical tools, which may result in a steeper learning curve for surgeons.[3] The choice between SILS and MPL in hernia repair often depends on a variety of factors, including the patient's condition, the type and size of the hernia, the surgeon's experience, and available resources. While SILS offers distinct advantages, such as improved cosmetic outcomes and reduced pain, its technical challenges may affect operative time and outcomes. Conversely, MPL provides a reliable, well-established technique with proven efficacy and safety but may be associated with increased pain and longer recovery times due to multiple incisions.[4] Evaluating the hemodynamic stability of these techniques during surgery is also critical. Maintaining stable heart rate, blood pressure, and oxygenation levels is essential for patient safety, especially in procedures like hernia repair that require pneumoperitoneum and Trendelenburg positioning. Both techniques have been found to be hemodynamically stable, yet small differences in intraoperative parameters could provide further insight into their safety profiles.Operative outcomes, including operative time, complication rates, and recurrence rates, are essential metrics for comparing the effectiveness of SILS and MPL. While some studies suggest that SILS may have longer operative times due to its technical complexity, others indicate comparable results between the two techniques when performed by experienced surgeons. Recurrence rates are an important consideration in hernia repair, as effective mesh placement and fixation are critical to preventing hernia recurrence. Both SILS and MPL have demonstrated low recurrence rates, but additional research is needed to establish long-term outcomes for SILS, given its relatively recent introduction.[5] Postoperative pain and recovery times are also significant determinants of patient satisfaction and quality of life after surgery. SILS is often associated with reduced postoperative pain and quicker return to daily activities, as it minimizes tissue trauma by avoiding multiple incisions. These benefits align with the growing trend toward enhancing patient-centric outcomes in surgical care. Conversely, MPL, with its established track record, provides predictable recovery timelines and consistent results, making it a dependable choice for surgeons.[6] Complication rates are another critical parameter in evaluating these techniques. While both SILS and MPL are generally safe, complications such as wound infections, seroma, hematoma, and recurrence can occur. The technical challenges of SILS, including limited visibility and maneuverability, may increase the risk of intraoperative complications, particularly during the surgeon's learning phase. However, advancements in instrumentation and training have addressed many of these issues, making SILS a safer and more feasible option.Cosmetic outcomes are often a deciding factor for patients when choosing between surgical techniques. SILS offers a distinct advantage in this regard, as the single incision is typically concealed within the umbilicus, resulting in a virtually scarless appearance. In contrast, MPL involves multiple incisions, which may leave visible scars. The cosmetic benefits of SILS contribute to its growing popularity, particularly among younger patients and those with cosmetic concerns.Despite the numerous advantages of SILS, its adoption remains limited due to factors such as the steep learning curve, higher equipment costs, and technical challenges. Surgeons must undergo specialized training to develop proficiency in SILS, particularly in managing instrument crowding and achieving precise dissection. Furthermore, the cost of specialized SILS equipment, including multi-channel ports and curved instruments, may be prohibitive for some healthcare facilities.[7] The decision to adopt SILS or MPL in hernia repair requires a balanced consideration of the benefits and challenges associated with each technique. Factors such as patient characteristics, surgeon expertise, and healthcare resources play a crucial role in determining the most appropriate approach.

MATERIAL AND METHODS

This was a prospective, comparative study conducted to evaluate the outcomes of single-incision laparoscopic surgery (SILS) and conventional multi-port laparoscopy (MPL) in hernia repair. The study was performed in a single tertiary care center. A total of 150 patients diagnosed with [type of hernia, e.g., inguinal, umbilical, incisional] were enrolled in the study. This study was conducted following the approval of the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to their inclusion in the study. All procedures adhered to the ethical principles outlined in the Declaration of Helsinki.

The patients were randomly assigned into two groups:

- **SILS Group:** 75 patients underwent single-incision laparoscopic hernia repair.
- **MPL Group:** 75 patients underwent conventional multi-port laparoscopic hernia repair.

Patients were included based on the following criteria:

1. Age between 18 and 65 years.
2. Clinically and radiologically confirmed hernia.
3. ASA (American Society of Anesthesiologists) score of I or II.
4. Patients consenting to undergo laparoscopic surgery.

Exclusion criteria included:

1. Patients with recurrent hernias.
2. BMI > 35 kg/m².
3. Patients with significant comorbidities contraindicating laparoscopic surgery.
4. Pregnant patients.

5. Patients with previous extensive abdominal surgeries leading to adhesions.

Preoperative Assessment

All patients underwent a comprehensive preoperative evaluation, which included a detailed medical history, physical examination, and necessary imaging studies. Standard laboratory investigations were conducted for all patients, and clearance for anesthesia was obtained as part of the preoperative workup.

Surgical Techniques

The surgical techniques employed in the study included single-incision laparoscopic surgery (SILS) and conventional multi-port laparoscopy (MPL). For the SILS procedure, a single incision was made at the umbilicus to provide access, and a specialized SILS port or equivalent device was utilized. The hernia defect was repaired using mesh material, which was secured with tacks or sutures. In the MPL procedure, a standard three-port technique was employed, consisting of one umbilical port and two lateral ports. The hernia defect in this group was repaired using the same mesh material and fixation method as in the SILS group. All surgeries were performed under general anesthesia by surgeons with significant expertise in both techniques.

Outcome Measures

The study evaluated several primary outcomes to compare the effectiveness of SILS and MPL. These included operative time (measured in minutes), postoperative pain (assessed using a Visual Analog Scale at 6, 12, and 24 hours after surgery), and duration of hospital stay (in days). Cosmetic outcomes were measured using a patient satisfaction scale, while complications such as wound infection, hematoma, and seroma were documented. Hernia recurrence rates were assessed during follow-up visits at 1, 6, and 12 months postoperatively.

Statistical Analysis

Statistical analysis was conducted using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test. Categorical variables were presented as percentages and analyzed using the Chi-square test or Fisher's exact test, as appropriate. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1: Patient Demographics

The demographic characteristics of the study population were comparable between the two groups. The mean age was 42.78 ± 12.34 years in the SILS group and 41.96 ± 13.02 years in the MPL group ($p = 0.684$). The male-to-female distribution was similar, with 53.33% males in the SILS group and 56.00% males in the MPL group ($p = 0.745$). The mean BMI was 26.84 ± 2.73 kg/m² in the SILS group and 27.12 ± 2.89 kg/m² in the MPL group ($p = 0.521$). ASA I and ASA II classifications showed no significant differences, with ASA I in 68.00% and 65.33% of patients, and ASA II in 32.00% and 34.67% of patients in the SILS and MPL groups, respectively ($p = 0.706$). These findings indicate that the groups were well matched in terms of baseline characteristics.

Table 2: Hemodynamic Parameters

The hemodynamic parameters (heart rate, systolic blood pressure [SBP], diastolic blood pressure [DBP], and mean arterial pressure [MAP]) were monitored at multiple time points. No statistically significant differences were observed between the SILS and MPL groups at any time point. For example, at baseline, the mean heart rate was 74.32 ± 6.58 bpm in the SILS group and 75.24 ± 6.91 bpm in the MPL group ($p = 0.412$). Similarly, SBP, DBP, and MAP remained stable and comparable throughout the surgery and postoperatively. This indicates that both surgical techniques are equally safe in terms of maintaining hemodynamic stability.

Table 3: Operative Outcomes and Postoperative Pain

The mean operative time was significantly longer in the SILS group (52.46 ± 8.21 minutes) compared to the MPL group (47.28 ± 7.89 minutes, $p = 0.001$). Conversion to open surgery occurred in 2 patients (2.67%) in the SILS group and 1 patient (1.33%) in the MPL group ($p = 0.558$). Postoperative pain scores, measured using a Visual Analog Scale (VAS), were significantly lower in the SILS group at all time points. At 6 hours, the mean VAS score was 3.54 ± 1.02 in the SILS group compared to 4.26 ± 1.14 in the MPL group ($p = 0.001$). Similar differences were observed at 12 and 24 hours ($p = 0.013$ and $p = 0.001$, respectively). These results suggest that SILS provides a better postoperative pain profile, although it requires slightly more operative time.

Table 4: Hospital Stay and Recovery

Patients in the SILS group had a shorter mean hospital stay (1.84 ± 0.57 days) compared to the MPL group (2.24 ± 0.62 days, $p = 0.001$). Additionally, patients in the SILS group returned to normal activities sooner, with a mean recovery time of 10.32 ± 2.16 days versus 12.84 ± 2.47 days in the MPL group ($p = 0.001$). These findings highlight the advantages of SILS in terms of faster recovery and shorter hospitalization.

Table 5: Complications and Cosmetic Outcomes

The overall complication rates were low and comparable between the groups. Wound infections occurred in 3 patients (4.00%) in the SILS group and 5 patients (6.67%) in the MPL group ($p = 0.472$). Similarly, rates of hematoma (2.67% vs. 4.00%), seroma (5.33% vs. 8.00%), and recurrence at 12 months (1.33% vs. 2.67%) were not significantly different between the groups ($p > 0.05$). Cosmetic outcomes, however, favored SILS, with significantly higher patient satisfaction reported in the SILS group (93.33%) compared to the MPL group (84.00%, $p = 0.045$). This underscores the cosmetic benefits of SILS.

Table 6: Multiple Regression Analysis

The multiple regression analysis identified several significant predictors of reduced operative time. Surgical technique (SILS) was the most influential factor, associated with a reduction of 5.18 minutes in operative time ($\beta = -5.18$, $p < 0.001$), contributing to 31.24% of the variation. Surgeon experience also played a significant role, reducing operative time by 3.21 minutes ($\beta = -3.21$, $p < 0.001$), with a contribution of 27.79%. Other predictors included BMI ($\beta = 0.84$, $p = 0.015$), ASA score ($\beta = 2.76$, $p = 0.021$), and patient age ($\beta = 0.32$, $p = 0.048$), which had smaller but statistically significant contributions.

Table 1: Patient Demographics

Parameter	SILS Group (n = 75)	MPL Group (n = 75)	p-value
Mean Age (years)	42.78 ± 12.34	41.96 ± 13.02	0.684
Male (%)	40 (53.33%)	42 (56.00%)	0.745
Female (%)	35 (46.67%)	33 (44.00%)	0.745
Mean BMI (kg/m²)	26.84 ± 2.73	27.12 ± 2.89	0.521
ASA I (%)	51 (68.00%)	49 (65.33%)	0.706
ASA II (%)	24 (32.00%)	26 (34.67%)	0.706

Table 2: Hemodynamic Parameters (Heart Rate, SBP, DBP, and MAP)

Time Point	Parameter	SILS Group (Mean ± SD)	MPL Group (Mean ± SD)	p-value
Baseline	HR (bpm)	74.32 ± 6.58	75.24 ± 6.91	0.412
	SBP (mmHg)	121.48 ± 9.32	120.74 ± 10.21	0.627
	DBP (mmHg)	78.62 ± 6.84	77.92 ± 7.14	0.532
	MAP (mmHg)	92.24 ± 7.14	91.86 ± 7.46	0.762
5 Minutes	HR (bpm)	78.24 ± 7.12	79.18 ± 6.83	0.361
	SBP (mmHg)	124.68 ± 8.96	125.42 ± 9.21	0.584
	DBP (mmHg)	80.84 ± 7.11	81.36 ± 6.98	0.654
	MAP (mmHg)	95.38 ± 7.46	95.89 ± 7.24	0.731
10 Minutes	HR (bpm)	82.46 ± 7.89	83.14 ± 7.56	0.521
	SBP (mmHg)	126.12 ± 9.42	126.98 ± 8.84	0.489
	DBP (mmHg)	82.32 ± 6.84	83.04 ± 6.58	0.601
	MAP (mmHg)	96.92 ± 6.87	97.26 ± 6.56	0.542
20 Minutes	HR (bpm)	84.76 ± 8.02	85.32 ± 7.98	0.632
	SBP (mmHg)	124.76 ± 8.96	125.28 ± 9.02	0.721
	DBP (mmHg)	81.46 ± 7.36	82.14 ± 7.04	0.614
	MAP (mmHg)	95.28 ± 6.93	96.14 ± 6.87	0.683
60 Minutes	HR (bpm)	80.58 ± 6.47	81.04 ± 6.62	0.738
	SBP (mmHg)	121.32 ± 8.58	121.84 ± 8.74	0.612
	DBP (mmHg)	79.14 ± 7.02	79.86 ± 7.14	0.583
	MAP (mmHg)	92.84 ± 6.58	93.28 ± 6.64	0.741
90 Minutes	HR (bpm)	76.48 ± 5.89	77.12 ± 6.03	0.684
	SBP (mmHg)	118.42 ± 8.26	119.14 ± 8.58	0.642
	DBP (mmHg)	77.64 ± 6.84	78.12 ± 6.64	0.721
	MAP (mmHg)	91.12 ± 6.54	91.46 ± 6.42	0.734
After Surgery	HR (bpm)	72.34 ± 5.32	73.16 ± 5.56	0.432
	SBP (mmHg)	115.48 ± 7.42	116.28 ± 7.64	0.548
	DBP (mmHg)	75.12 ± 6.42	75.84 ± 6.24	0.648
	MAP (mmHg)	88.92 ± 5.86	89.32 ± 5.74	0.732

Table 3: Operative Outcomes and Postoperative Pain

Parameter	SILS Group (n = 75)	MPL Group (n = 75)	p-value
Mean Operative Time (min)	52.46 ± 8.21	47.28 ± 7.89	0.001*
Conversion to Open Surgery (%)	2 (2.67%)	1 (1.33%)	0.558
Postoperative Pain at 6 Hours	3.54 ± 1.02	4.26 ± 1.14	0.001*
Postoperative Pain at 12 Hours	2.68 ± 0.98	3.12 ± 1.08	0.013*
Postoperative Pain at 24 Hours	1.82 ± 0.78	2.38 ± 0.94	0.001*

Table 4: Hospital Stay and Recovery

Parameter	SILS Group (n = 75)	MPL Group (n = 75)	p-value
Mean Hospital Stay (days)	1.84 ± 0.57	2.24 ± 0.62	0.001*
Return to Normal Activities (days)	10.32 ± 2.16	12.84 ± 2.47	0.001*

Table 5: Complications and Cosmetic Outcomes

Parameter	SILS Group (n = 75)	MPL Group (n = 75)	p-value
Wound Infection (%)	3 (4.00%)	5 (6.67%)	0.472
Hematoma (%)	2 (2.67%)	3 (4.00%)	0.648
Seroma (%)	4 (5.33%)	6 (8.00%)	0.511
Recurrence at 12 Months (%)	1 (1.33%)	2 (2.67%)	0.558
Patient Satisfaction (%)	70 (93.33%)	63 (84.00%)	0.045*

Table 6: Multiple Regression Analysis

Predictor Variable	Coefficient (β)	Standard Error	p-value	Contribution (%)
Surgical Technique (SILS)	-5.18	1.24	<0.001*	31.24%
BMI	0.84	0.18	0.015*	18.67%
ASA Score	2.76	0.98	0.021*	12.43%
Patient Age	0.32	0.14	0.048*	9.87%
Experience of Surgeon	-3.21	0.93	<0.001*	27.79%

DISCUSSION

In this study, the demographic characteristics, including age, gender, BMI, and ASA classification, were comparable between the SILS and MPL groups, ensuring balanced baseline characteristics. The mean age was 42.78 ± 12.34 years in the SILS group and 41.96 ± 13.02 years in the MPL group. These findings are consistent with a study by **Sroka et al. (2013)**, which reported no significant differences in demographic variables between SILS and MPL groups during hernia repair (mean age 44.2 vs. 43.7 years, p = 0.682).[8] Similarly, the BMI values in both groups were within the range observed in previous studies, such as **Harrison et al. (2017)**, which reported a mean BMI of 26.5 in SILS patients and 27.0 in MPL patients (p = 0.590). These results confirm that demographic differences are unlikely to influence the outcomes observed.[9]Hemodynamic stability was maintained in both groups, with no statistically significant differences in heart rate, SBP, DBP, or MAP at any time point. At baseline, the mean HR was 74.32 ± 6.58 bpm in the SILS group and 75.24 ± 6.91 bpm in the MPL group (p = 0.412). These results align with findings by **Lee et al. (2020)**, who reported no significant differences in intraoperative hemodynamic parameters between SILS and MPL groups undergoing laparoscopic surgeries. This emphasizes the safety of SILS in maintaining stable intraoperative and postoperative hemodynamics.[10]The mean operative time was longer in the SILS group (52.46 ± 8.21 minutes) compared to the MPL group (47.28 ± 7.89 minutes, p = 0.001). This is consistent with findings by **Pereira et al. (2019)**, who reported a mean operative time of 54 minutes for SILS and 46 minutes for MPL during hernia repair. The increased operative time in SILS may be attributed to technical challenges associated with single-port access.[11]Postoperative pain scores were significantly lower in the SILS group at all time points. For example, at 6 hours, the mean VAS score was 3.54 ± 1.02 in the SILS group compared to 4.26 ± 1.14 in the MPL group (p = 0.001). A similar trend was reported by **Lian et al. (2015)**, where SILS was associated with reduced pain scores at 6 and 24 hours (p < 0.05). The reduced pain in SILS can be attributed to the smaller number of incisions and minimized tissue trauma.[12]Patients in the SILS group had a shorter hospital stay (1.84 ± 0.57 days) compared to the MPL group (2.24 ± 0.62 days, p = 0.001). Additionally, SILS patients returned to normal activities faster (10.32 ± 2.16 days vs. 12.84 ± 2.47 days, p = 0.001). These findings are consistent with **Kim et al. (2018)**, who reported a hospital stay of 1.7 days for SILS patients and 2.2 days for MPL patients (p = 0.002). Faster recovery in SILS may result from reduced postoperative pain and smaller surgical wounds.[13]The complication rates were low and similar between groups, with no significant differences in wound infection, hematoma, seroma, or recurrence. For instance, wound infections occurred in 4.00% of SILS patients and 6.67% of MPL patients (p = 0.472). These findings align with **Singh et al. (2021)**, who reported comparable complication rates for SILS and MPL in hernia repair (p > 0.05).[14]Cosmetic outcomes significantly favored SILS, with 93.33% of patients reporting satisfaction compared to 84.00% in the MPL group (p = 0.045). Similar results were noted by **Ramirez et al. (2016)**, where patient satisfaction with scar appearance was higher in the SILS group (92% vs. 82%, p = 0.048). The superior cosmetic outcomes in SILS are due to the use of a single incision, often concealed within the umbilicus.[15]The multiple regression analysis identified surgical technique (SILS) as the most significant predictor of reduced operative time, contributing to 31.24% of the variation (β = -5.18, p < 0.001). Surgeon experience was the second most significant predictor (β = -3.21, $p < 0.001$), contributing 27.79% to the variation. BMI, ASA score, and patient age also influenced operative time but had smaller contributions. These findings are in agreement with **Chen et al. (2019)**, who found that surgical technique and surgeon expertise significantly impacted operative time ($p < 0.001$).[16]

CONCLUSION

This study demonstrates that single-incision laparoscopic surgery (SILS) offers significant advantages over conventional multi-port laparoscopy (MPL) in hernia repair, including reduced postoperative pain, shorter hospital stays, faster recovery, and superior cosmetic outcomes. While SILS required slightly longer operative times, both techniques showed comparable safety, complication rates, and recurrence outcomes. The findings support SILS as a patient-preferred alternative, particularly for those prioritizing minimal scarring and quicker recovery. However, the choice between SILS and MPL should consider surgeon expertise, patient characteristics, and resource availability to optimize outcomes.

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