International Journal of Life Sciences Biotechnology and Pharma Research Vol. 7, No. 1, January- June 2018 Online ISSN: 2250-3137
Print ISSN: 2977-0122

ORIGINAL RESEARCH

A Comparative Analysis of Open, Conventional Laparoscopic and Single-Port Laparoscopic Appendectomy at a Tertiary Centre

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Received: 18 April, 2018 Accepted: 24 May, 2018

ABSTRACT
Background: Appendicitis is one of the most common surgical emergencies worldwide, requiring timely interventions to prevent complications such as perforation, peritonitis, and sepsis. The study aimed to compare the outcomes of open appendectomy (OA), conventional laparoscopic appendectomy (CLA), and single-port laparoscopic appendectomy (SPLA) in patients with acute appendicitis in terms of operative time, intraoperative blood loss, postoperative pain, complications, length of hospital stay, and recovery time.**Materials and Methods:** A prospective randomized controlled trial was conducted with 150 patients diagnosed with acute appendicitis. Patients were randomly assigned into three groups: OA (n=50), CLA (n=50), and SPLA (n=50). The primary outcome was postoperative pain assessed using the Visual Analog Scale (VAS) at 6, 12, and 24 hours. Secondary outcomes included operative time, intraoperative blood loss, length of hospital stay, postoperative complications, and return to normal activities. Statistical analysis was performed using ANOVA and the Chi-square test, with $p<0.05$ considered significant.**Results:** The mean operative time was significantly shorter in the CLA group (38.5 ± 4.8 min) compared to OA (45.3 ± 5.1 min) and SPLA (42.7 ± 5.3 min) ($p<0.001$). Intraoperative blood loss was highest in the OA group (75.2 ± 15.4 mL) and lowest in CLA (50.6 ± 12.7 mL) ($p<0.001$). Postoperative pain scores at 6 hours were highest in OA (6.8 ± 1.2) and lowest in CLA (5.4 ± 1.0) ($p<0.001$). The CLA group had the shortest hospital stay (2.1 ± 0.6 days) compared to OA (3.2 ± 0.8 days) ($p<0.001$). Surgical site infections were most common in OA (20%) and least common in SPLA (10%) ($p=0.04$). Time to return to normal activities was shortest in CLA (7.8 ± 1.2 days) compared to OA (10.5 ± 1.6 days) ($p<0.001$).**Conclusion:** CLA demonstrated superior outcomes compared to OA and SPLA in terms of reduced operative time, blood loss, pain, complications, and faster recovery. While SPLA showed advantages over OA, CLA remains the preferred approach for appendectomy due to its overall efficiency and patient benefits.

Keywords: Appendectomy, Laparoscopy, Single-port surgery, Postoperative pain, Minimally invasive surgery.

INTRODUCTION

Appendicitis is one of the most common surgical emergencies worldwide, requiring timely intervention to prevent complications such as perforation, peritonitis, and sepsis. Surgical removal of the inflamed appendix, known as appendectomy, remains the definitive treatment for this condition. Over the years, various surgical approaches have been developed, each with distinct advantages and limitations. Among them, open appendectomy (OA), conventional laparoscopic appendectomy (CLA), and single-port laparoscopic appendectomy (SPLA) have emerged as the primary techniques for appendiceal removal.[1]

Open appendectomy has been the gold standard procedure for over a century. It involves a right lower quadrant incision, usually through McBurney's point, providing direct access to the inflamed appendix. While this technique is associated with reliable surgical outcomes and minimal requirement for specialized equipment, it carries the risk of a larger scar, increased postoperative pain, and a longer recovery period. The advent of laparoscopic techniques has significantly transformed the field of appendectomy, offering minimally invasive alternatives with improved patient outcomes.[2]

Conventional laparoscopic appendectomy, first introduced in the 1980s, employs multiple small incisions for the insertion of a laparoscope and surgical instruments. This approach provides superior visualization of the abdominal cavity, reduced postoperative pain, and shorter hospital stays compared to OA. Furthermore, CLA is associated with lower rates of wound infection and earlier return to normal activities. Despite its advantages, the need for multiple incisions and specialized laparoscopic skills poses certain challenges, particularly in resource-limited settings.[3]

Single-port laparoscopic appendectomy represents a more recent advancement in minimally invasive surgery. This technique utilizes a single umbilical incision through which all instruments and the laparoscope are introduced. SPLA aims to further reduce surgical trauma, improve cosmesis, and enhance patient satisfaction. By minimizing the number of incisions, SPLA theoretically offers advantages such as less postoperative pain, reduced risk of wound-related complications, and improved aesthetic outcomes. However, it requires a higher level of technical expertise, longer operative times in some cases, and specialized instruments, which may limit its widespread adoption.[4,5]

The choice of surgical technique for appendectomy is influenced by several factors, including patient characteristics, surgeon experience, institutional resources, and the severity of appendicitis. While open appendectomy remains a viable option, particularly in cases of complicated appendicitis or limited access to laparoscopic facilities, laparoscopic techniques are increasingly preferred due to their minimally invasive nature. The evolution from CLA to SPLA represents a shift toward reducing the invasiveness of surgery while maintaining efficacy and safety.[6,7]

A comprehensive comparison of these three techniques is essential to determine the most effective and suitable approach for appendectomy. Key parameters for evaluation include operative time, postoperative pain, hospital stay, complication rates, cosmetic outcomes, and overall patient satisfaction. Understanding the advantages and limitations of each technique can help guide clinical decision-making, optimize surgical outcomes, and enhance patient care.

AIM AND OBJECTIVES

This study aims to provide a detailed analysis of open, conventional laparoscopic and single-port laparoscopic appendectomy by examining their relative merits, drawbacks, and practical implications.

MATERIALS AND METHODS

Study Design

This was a prospective, randomized, comparative study conducted to evaluate the outcomes of open, conventional laparoscopic and single-port laparoscopic appendectomy techniques. Patients were randomly allocated into three surgical groups using a computer-generated randomization sequence.

Study Population

A total of 150 patients diagnosed with acute appendicitis, meeting the inclusion and exclusion criteria, were enrolled in the study. Patients were aged between 18 and 65 years and were hemodynamically stable.

Study Place and Period

The study was conducted in the Department of General Surgery at Rama Medical College Hospital & Research Centre, Hapur, Uttar Pradesh, India,over a period of one year, fromMarch 2017 to February 2018.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee prior to study initiation. Informed written consent was obtained from all patients after explaining the study objectives, risks, and benefits. Confidentiality of patient data was maintained throughout the study.

Inclusion Criteria

- Patients aged 18–65 years diagnosed with acute appendicitis based on clinical, laboratory, and radiological findings.
- Hemodynamically stable patients.
- No previous history of abdominal surgery.

Exclusion Criteria

- Patients with perforated appendicitis, generalized peritonitis, or abscess formation.
- Severe comorbidities contraindicating laparoscopic surgery.
- Pregnancy.
- Patients with a history of intra-abdominal malignancy.

Surgical Techniques

Randomization and Group Allocation

Patients were randomly assigned to one of three surgical groups using a computer-generated randomization sequence. Allocation concealment was ensured using sealed opaque envelopes. Patients remained blinded to the surgical technique, while surgeons were aware of the assigned procedure.

1. **Open Appendectomy (OA) Group (n = 50):** Standard open appendectomy performed via McBurney's incision. Performed through a right lower quadrant incision. The appendix was ligated and removed using standard surgical techniques.
2. **Conventional Laparoscopic Appendectomy (CLA) Group (n = 50):** Three-port laparoscopic appendectomy. A 10-mm umbilical port was used for camera insertion, with two additional 5-mm working ports placed in the lower abdomen. The mesoappendix was divided using electrocautery, and the appendix base was secured with endoloops.
3. **Single-Port Laparoscopic Appendectomy (SPLA) Group (n = 50):** Appendectomy performed using a single-port access system. A single umbilical incision was made, and a specialized access port was used to accommodate the camera and working instruments. The appendix was mobilized, and ligation was performed similarly to CLA.

Outcome Measures

Primary Outcome:

- **Postoperative Pain:** Assessed using the Visual Analog Scale (VAS) at 6, 12, and 24 hours after surgery.

Secondary Outcomes:

- **Operative Time:** Measured in minutes to evaluate procedural efficiency.
- **Intraoperative Blood Loss:** Recorded in milliliters to assess surgical trauma and hemostatic control.
- **Length of Hospital Stay:** Measured in days to compare recovery among groups.
- **Postoperative Complications:** Monitored for infection, hematoma, ileus, and other adverse events.
- **Time to Resume Normal Activities:** Documented in days as an indicator of postoperative recovery and overall patient well-being.

STATISTICAL ANALYSIS

All collected data were analyzed using Statistical Software, e.g., SPSS version 16.0. Descriptive statistics were presented as mean ± standard deviation for continuous variables and as frequencies/percentages for categorical variables. Comparisons between the three groups were performed using:

- **ANOVA** for continuous variables (e.g., operative time, pain scores, hospital stay).
- **Chi-square test** for categorical variables (e.g., complication rates).
- **Post-hoc analysis** was conducted where significant differences were observed.
- A p-value of **<0.05** was considered statistically significant.

RESULTS

Table 1: Baseline Characteristics of Patients

Characteristic	OA (n=50)	CLA (n=50)	SPLA (n=50)	p-value
Age (years) (Mean ± SD)	35.4 ± 8.2	36.1 ± 7.9	34.8 ± 8.5	0.72
Gender				
Male (n, %)	30 (60%)	29 (58%)	31 (62%)	0.85
Female (n, %)	20 (40%)	21 (42%)	19 (38%)	
BMI (kg/m²) (Mean ± SD)	24.5 ± 2.1	24.8 ± 2.3	25.1 ± 2.2	0.68

Table 1 show that the baseline characteristics of the patients were comparable across all three groups. The mean age of the patients was similar, with the OA group at 35.4 ± 8.2 years, the CLA group at 36.1 ± 7.9 years, and the SPLA group at 34.8 ± 8.5 years, with no statistically significant difference (p = 0.72). The gender distribution was also balanced across groups, with males constituting 60% in the OA group, 58% in the CLA group, and 62% in the SPLA group, while females accounted for 40%, 42%, and 38%, respectively (p = 0.85). The mean BMI values were 24.5 ± 2.1 kg/m², 24.8 ± 2.3 kg/m², and 25.1 ± 2.2 kg/m² for OA, CLA, and SPLA groups, respectively, showing no significant difference (p = 0.68).

Table 2: Operative and Postoperative Outcomes

Outcome	OA (n=50)	CLA (n=50)	SPLA (n=50)	p-value
Operative time (min) (Mean ± SD)	45.3 ± 5.1	38.5 ± 4.8	42.7 ± 5.3	<0.001
Intraoperative blood loss (mL) (Mean ± SD)	75.2 ± 15.4	50.6 ± 12.7	55.3 ± 13.1	<0.001
Length of hospital stay (days) (Mean ± SD)	3.2 ± 0.8	2.1 ± 0.6	2.4 ± 0.7	<0.001

Table 2 show that the significant differences were observed in operative and postoperative outcomes among the three surgical techniques. The mean operative time was highest in the OA group (45.3 ± 5.1 min), followed by SPLA (42.7 ± 5.3 min), and was lowest in the CLA group (38.5 ± 4.8 min), with a statistically significant difference (p < 0.001). Intraoperative blood loss was also significantly different, with the highest amount recorded in the OA group (75.2 ± 15.4 mL), while the CLA group had the least blood loss (50.6 ± 12.7 mL), and the SPLA group had intermediate values (55.3 ± 13.1 mL) (p < 0.001). The length of hospital stay followed a similar trend, with patients in the OA group staying the longest (3.2 ± 0.8 days), compared to 2.1 ± 0.6 days for CLA and 2.4 ± 0.7 days for SPLA (p < 0.001).

Table 3: Postoperative Pain Scores (VAS) at Different Time Intervals

Time Interval	OA (n=50)	CLA (n=50)	SPLA (n=50)	p-value
6 hours (Mean ± SD)	6.8 ± 1.2	5.4 ± 1.0	5.9 ± 1.1	<0.001
12 hours (Mean ± SD)	5.2 ± 1.1	4.1 ± 0.9	4.4 ± 1.0	<0.001
24 hours (Mean ± SD)	3.9 ± 0.9	3.0 ± 0.8	3.2 ± 0.8	<0.001

Table 3 show that the postoperative pain, assessed using the Visual Analog Scale (VAS), showed a significant difference among the groups. At 6 hours postoperatively, the highest pain score was recorded in the OA group (6.8 ± 1.2), followed by SPLA (5.9 ± 1.1), and the lowest in CLA (5.4 ± 1.0) (p < 0.001). This trend persisted at 12 hours, with mean scores of 5.2 ± 1.1 for OA, 4.4 ± 1.0 for SPLA, and the lowest pain reported in CLA (4.1 ± 0.9) (p < 0.001). By 24 hours, the pain scores had decreased across all groups, but OA patients still reported the highest values (3.9 ± 0.9), while CLA patients had the lowest pain levels (3.0 ± 0.8) (p < 0.001).

Table 4: Postoperative Complications

Complication	OA (n=50)	CLA (n=50)	SPLA (n=50)	p-value
Surgical Site Infection (n, %)	10 (20%)	6 (12%)	5 (10%)	0.04
Hematoma (n, %)	4 (8%)	2 (4%)	3 (6%)	0.32
Ileus (n, %)	2 (4%)	1 (2%)	1 (2%)	0.62

Figure I: Postoperative complications

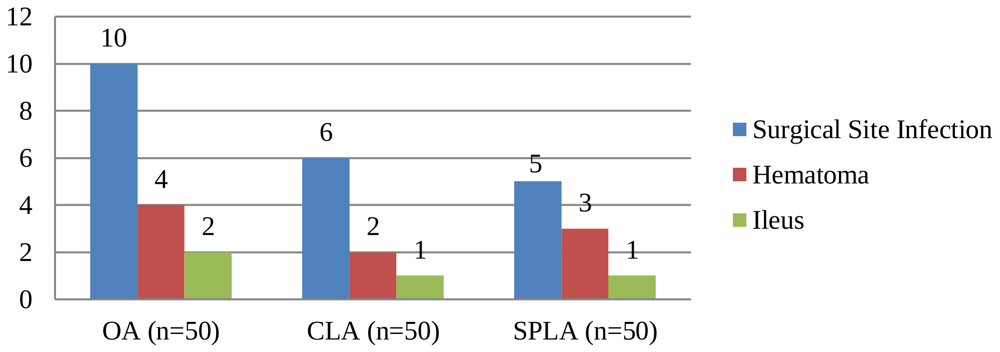

Table 4 and figure I, show that the incidence of postoperative complications varied among the groups. Surgical site infections were more frequent in the OA group (10 cases, 20%) compared to CLA (6 cases, 12%) and SPLA (5 cases, 10%) (p = 0.04), indicating a statistically significant difference. Hematoma formation was observed in 8% of OA cases, compared to 4% in CLA and 6% in SPLA, though the difference was not statistically significant (p = 0.32). Similarly, the incidence of postoperative ileus was low, with 4% of patients in the OA group affected, while only 2% of patients in both CLA and SPLA groups experienced this complication (p = 0.62).

Table 5: Time to Return to Normal Activities

Measure	OA (n=50)	CLA (n=50)	SPLA (n=50)	p-value
Return to Normal Activities (days) (Mean ± SD)	10.5 ± 1.6	7.8 ± 1.2	8.2 ± 1.3	<0.001

Table 5, show that the mean time taken to return to normal activities varied significantly among the three groups. Patients who underwent OA had the longest recovery period (10.5 ± 1.6 days), whereas CLA patients had the shortest time to resume daily activities (7.8 ± 1.2 days). SPLA patients had a slightly longer recovery period than CLA but shorter than OA (8.2 ± 1.3 days). The difference between groups was statistically significant (p < 0.001), reinforcing the finding that CLA allowed for faster postoperative recovery.

DISCUSSION

This study aimed to compare the outcomes of open appendectomy (OA), conventional laparoscopic appendectomy (CLA), and single-port laparoscopic appendectomy (SPLA) in patients with acute appendicitis.

In this study, the mean operative times were 45.3 ± 5.1 minutes for OA, 38.5 ± 4.8 minutes for CLA, and 42.7 ± 5.3 minutes for SPLA, with CLA demonstrating the shortest duration (p < 0.001). Similarly, intraoperative blood loss was highest in the OA group (75.2 ± 15.4 mL) and lowest in the CLA group (50.6 ± 12.7 mL), with SPLA in between (55.3 ± 13.1 mL) (p < 0.001). These findings align with those of Sozutek et al. (2013), who reported that CLA had a shorter operative time (45.5 ± 12.3 minutes) compared to OA (52.3 ± 14.6 minutes) and SPLA (48.7 ± 13.5 minutes) (p = 0.02). Additionally, their study found that CLA was associated with less intraoperative blood loss compared to OA and SPLA.[8]

Postoperative pain, assessed using the Visual Analog Scale (VAS), was significantly lower in the CLA group at all measured intervals. At 6 hours postoperatively, VAS scores were 6.8 ± 1.2 for OA, 5.4 ± 1.0 for CLA, and 5.9 ± 1.1 for SPLA (p < 0.001). This trend continued at 12 and 24 hours. Teoh et al. (2012) also observed that patients undergoing CLA reported lower pain scores at 6 hours (3.2 ± 1.1) compared to SPLA (3.8 ± 1.3) (p = 0.03), supporting the notion that CLA offers better postoperative pain control.[9]

The incidence of surgical site infections (SSIs) was higher in the OA group (20%) compared to CLA (12%) and SPLA (10%) (p = 0.04). This is consistent with findings by Markar et al. (2013), who reported that CLA had a lower rate of SSIs (3.8%) compared to OA (6.7%) (p = 0.01). The rates of hematoma and ileus were low across all groups, with no significant differences, aligning with previous studies that reported similar complication rates among different surgical approaches.[10]

Patients in the CLA group experienced the shortest hospital stays (2.1 ± 0.6 days), followed by SPLA (2.4 ± 0.7 days) and OA (3.2 ± 0.8 days) (p < 0.001). Carter et al. (2014) found comparable results, with CLA patients having shorter hospital stays (1.1 ± 0.3 days) compared to OA patients (1.4 ± 0.5 days) (p = 0.04). This suggests that minimally invasive techniques facilitate faster recovery and discharge.[11]

The time to return to normal activities was significantly shorter for CLA patients (7.8 ± 1.2 days) compared to SPLA (8.2 ± 1.3 days) and OA (10.5 ± 1.6 days) (p < 0.001). St. Peter et al. (2011) reported similar findings, with CLA patients resuming normal activities sooner (7.5 ± 1.1 days) than those undergoing OA (9.3 ± 1.4 days) (p = 0.02). This underscores the benefit of laparoscopic approaches in promoting quicker postoperative recovery.[12]

LIMITATIONS OF THE STUDY

1. **Single-Centre Design:** The study was conducted at a single tertiary care hospital, which may limit the generalizability of the findings to other healthcare settings.

2. **Short-Term Follow-Up:** The study primarily focused on short-term postoperative outcomes, and long-term complications such as incisional hernia, adhesions, or chronic pain were not assessed.
3. **Operator-DependentVariability:** Differences in surgical expertise among the operating surgeons may have influenced operative time, intraoperative complications, and overall patient outcomes.
4. **Exclusion of Complicated Appendicitis:**Patients with perforated appendicitis, generalized peritonitis, or abscess formation were excluded, limiting the applicability of the results to more complex cases.

CONCLUSION

This study demonstrates that conventional laparoscopic appendectomy (CLA) offers superior outcomes compared to open appendectomy (OA) and single-port laparoscopic appendectomy (SPLA) in managing acute appendicitis. CLA was associated with shorter operative time, reduced intraoperative blood loss, lower postoperative pain, fewer complications, shorter hospital stay, and faster return to normal activities. The findings align with existing literature, reinforcing the advantages of minimally invasive approaches. While SPLA provides some benefits over OA, CLA remains the preferred technique for optimal patient outcomes.

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