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ORIGINAL ARTICLE

Comparison of surgical outcomes of laparoscopic and open appendectomy for perforated Appendicitis: In terms of surgical site infections, operative time hospital stay and postoperative recovery.

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ABSTRACT… Objective: To compare the frequency of SSIs, operative time, length of hospital stay, and time to return to routine activities between LA and OA in patients with perforated appendicitis. **Study Design:** Randomized Control Trial. **Setting:** Department of General Surgery, Allied Hospital, Faisalabad. **Period:** October 31, 2021, to April 30, 2022. **Methods:** A total of 230 patients, aged 15–50 years, with intraoperatively confirmed perforated appendicitis, were enrolled using non-probability consecutive sampling. Patients with negative appendectomy or non-perforated appendix on operation, pregnant females, immune-compromized and DM were excluded. Participants were assigned to undergo either LA (Group A, n=115) or OA (Group B, n=115). Consultant surgeons performed all procedures with at least three years of post-fellowship experience. Primary outcomes included SSIs (tracked for four weeks postoperatively), operative time (minutes), hospital stay (days), and time to resume routine activities (days). **Results:** The mean age of patients in group A was 34.60 ± 7.77 years and in group B was 35.61 ± 8.17 years. Majority of the patients 127 (55.22%) were between 15 to 35 years of age. Out of 230 patients 153 (66.52%) were males and 77 (33.48%) were females with male to female ratio of 2:1. SSIs occurred in 4.35% of patients undergoing LA versus 11.30% in the OA group (p=0.049). LA had a significantly longer operative time (74 ± 15 vs. 50.9 ± 15 minutes, p<0.0001) but resulted in a shorter hospital stay (2.4 ± 0.6 vs. 3.7 ± 2.5 days, p=0.03). A highly significant difference existed between 2 groups in time taken to return to normal routine activities, less in group A (LA) with means 14.4±3.1 vs 18.1±3.3 days with p value 0.0001. LA remained superior in reducing wound infections overall. **Conclusion:** In patients with perforated appendicitis, laparoscopic appendectomy significantly lowers the risk of SSIs, shortens hospital stay, and facilitates an earlier return to daily activities, despite a moderately longer operative time.

Key words: Hospital Stay, Laparoscopic Appendectomy, Open Appendectomy, Postoperative Recovery, Perforated Appendicitis, Surgical Site Infections, SSI.

INTRODUCTION

Acute appendicitis is an inflammatory condition of the appendix. It is most commonly caused by luminal obstruction due to fecalith, stricture, or lymphoid hyperplasia. It is the most common surgical emergency in the world. The condition typically occurs more often in males aged between 15 and 25 years, but it can happen to all age groups.[1]

For more than a century, McBurney's 1894 description and the subsequent standard surgical treatment for appendicitis have been the open appendectomy (OA).[2] Laparoscopic appendectomy (LA), started in the 1980s, first performed by Kurt Semm, revolutionized the field of minimally invasive surgery. There still is disagreement on whether LA (laparoscopic appendectomy) or OA (open appendectomy) should be the operative of choice, even though the latter is gaining over.[3] The operative time for LA is greater than that of OA.[4] The latter is also associated with postoperative abdominal abscess formation.[4]

LA has risen in popularity, especially among

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the elderly and obese patients, because of its minimally invasive approach, lesser pain, and better cosmetic results. In the general population, there continues to be controversy over whether LA is ultimately more beneficial than OA, especially in perforated appendicitis cases.[5] SSIs contribute significantly to patient morbidity, leading to delayed recovery, prolonged hospital stays, pain, and potential disability.[6] Identifying risk factors and implementing preventive strategies for SSIs are crucial for improving surgical outcomes. Besides infection rates, factors such as operative time, duration of hospital stay, and time to return to routine activities also play a key role in determining the preferred surgical technique for appendectomy.

Given the variability in the existing literature on SSI rates after an appendectomy, this study was conducted in a tertiary care hospital catering to a large, low-socioeconomic population with a high burden of complicated cases. This research aims to provide practical recommendations for minimising SSIs and optimising surgical outcomes by comparing LA and OA for perforated appendicitis. Specifically, we evaluated the frequency of SSIs, operative time, hospital stay, and time taken to resume daily activities in patients undergoing either approach.

OPERATIONAL DEFINITIONS

- **Perforated appendicitis:** All patients with presence of all these i.e. history of pain (VAS = 3-10) in right iliac fossa with rebound tenderness, elevated WBC's (>11,000) and perforated appendix on surgical findings were taken as positive.
- **Surgical site infections (SSIs):** presence of purulent discharge and resulting in opening of the skin wound within 4 weeks after operation was deemed as positive.

METHODS

This randomized control trial was conducted at the Department of General Surgery, Allied Hospital, Faisalabad (affiliated with Faisalabad Medical University) from October 31, 2021, to April 30, 2022, after obtaining ethical approval from the Institutional Ethical Review Committee of Faisalabad Medical University (IRB Approval no.IRB0006912, OHRP-registered; dated November 7, 2020).

The study included 230 patients (115 per group) selected through non-probability consecutive sampling, with inclusion criteria comprising patients aged 15-50 years of both genders presenting with symptoms lasting more than 12 hours and intraoperatively confirmed perforated appendicitis. Exclusion criteria eliminated patients with negative or non-perforated appendicitis, pregnant females, immunocompromised individuals, and those with diabetes mellitus (FBS >110 mg/dL on two consecutive occasions).

After obtaining informed written consent, patients were allocated via computer-generated numbers into either the laparoscopic appendectomy (Group A) or the open appendectomy (Group B) groups. All procedures were performed by consultant surgeons with at least three years of post-fellowship experience, with patients receiving preoperative 1-gram ceftriaxone injections and postoperative broad-spectrum antibiotics for five days. Primary outcomes measured surgical site infection (SSI) rates over four weeks, while secondary outcomes included operative time (from insufflation to skin closure), hospital stay duration, and recovery time. Patients were followed regularly up to 4 weeks post-operatively for time taken to return to routine activities and presence or absence of surgical site infections. All this data (age, gender and surgical site infection) was recorded on a pre-designed proforma (Annexure I).

Data analysis using SPSS version 25.0 included descriptive statistics (mean ± SD for continuous variables; frequencies/percentages for categorical variables) and inferential statistics (Chi-square tests for SSI comparisons with reported alongside p-values, considering $p \leq 0.05$ significant). Stratification controlled for age, gender, symptom duration, and BMI, with post-stratification chi-square analysis assessing their impact on SSI rates. The study complied with all IRB requirements, including protocol adherence and reporting timelines.

RESULTS

A total of 230 patients aged 15 to 50 years were included in this study, with a mean age of 34.67 ± 7.98 years. The mean age was 34.60 ± 7.77 years in Group A (laparoscopic appendectomy, LA) and 35.61 ± 8.17 years in Group B (open appendectomy, OA). The majority of patients (55.22%) were between 15 and 35 years.

Among the participants, 153 (66.52%) were male and 77 (33.48%) were female, resulting in a male-to-female ratio of 2:1. The mean duration of symptoms before surgery was 30.55 ± 9.33 hours, with 65.65% of patients experiencing symptoms for more than 24 hours. The mean BMI of patients was 28.43 ± 3.35 kg/m^2, with a slightly higher proportion of patients having a BMI >27 kg/m^2. (Table-I)

Surgical site infections (SSIs) were observed in 5 patients (4.35%) in Group A (LA) and 13 patients (11.30%) in Group B (OA), showing a statistically significant difference ($p = 0.049$). The mean operative time was significantly longer in Group A (LA) (74 ± 15 minutes) compared to Group B (OA) (50.9 ± 15 minutes, $p < 0.0001$). However, patients in Group A (LA) had a significantly shorter hospital stay (2.4 ± 0.6 days) compared to Group B (OA) (3.7 ± 2.5 days, $p = 0.03$). Furthermore, patients who underwent LA resumed normal routine activities earlier (14.4 ± 3.1 days) compared to those who underwent OA (18.1 ± 3.3 days, $p < 0.0001$). (Table-II)

Stratification analysis showed variations in SSI rates based on age, gender, symptom duration, and BMI. (Table-III)

Laparoscopic appendectomy, although taking longer to perform, is associated with fewer SSIs, shorter hospital stay, and quicker return to daily life compared to open surgery, making it a favorable option in managing perforated appendicitis. SSI risk increases with older age, prolonged symptoms, and higher BMI, especially in the open appendectomy group. Laparoscopic appendectomy offers a relative protective advantage against SSIs across most subgroups, particularly in patients with symptoms >24 hours.

Variable	Group A (LA)(n=115)	Group B (OA)(n=115)	Total (n=230)
Age Distribution			
15–35 years	68 (59.13%)	59 (51.30%)	127 (55.22%)
36–50 years	47 (40.87%)	56 (48.70%)	103 (44.78%)
Mean ± SD (years)	34.60 ± 7.77	35.61 ± 8.17	34.67 ± 7.98
Gender Distribution			
Male	75 (65.22%)	78 (67.83%)	153 (66.52%)
Female	40 (34.78%)	37 (32.17%)	77 (33.48%)
Duration of Symptoms			
≤24 hours	34 (29.57%)	45 (39.13%)	79 (34.35%)
>24 hours	81 (70.43%)	70 (60.87%)	151 (65.65%)
Mean ± SD (hours)	31.39 ± 8.84	30.02 ± 10.28	30.55 ± 9.33
BMI (kg/m^2)			
≤27	52 (45.22%)	51 (44.35%)	103 (44.78%)
>27	63 (54.78%)	64 (55.65%)	127 (55.22%)
Mean ± SD	28.35 ± 3.32	28.64 ± 3.44	28.43 ± 3.35

Table-I. Demographic and clinical characteristics of patients (n=230)

Variables	Group A (LA) (n=115)	Group B (OA) (n=115)	P-Value
Surgical site infection	5 (4.35 %)	13 (11.3%)	0.049
Operative time (mins)	74 ± 15	50.9 ± 15	0.001
Duration of hospital stay (days)	2.4 ± 0.6	3.7 ± 2.5	0.030
Time taken to return to routine (days)	14.4 ± 3.1	18.1 ± 3.3	0.001

Table-II. Comparison of the different variables between laparoscopic versus open appendectomy for perforated appendixe.

Effect Modifier		Group A (n=115)		Group B (n=115)		P-Value
		SSI		SSI		
		Yes	No	Yes	No	
Age of patients (years)	15-35	04 (5.88%)	64 (94.12%)	06 (10.17%)	53 (89.83%)	0.371
	36-50	01 (2.13%)	46 (97.87%)	07 (12.50%)	49 (87.50%)	0.050
Gender	Male	02 (2.67%)	73 (97.33%)	06 (7.69%)	72 (92.31%)	0.163
	Female	03 (7.50%)	37 (92.50%)	07 (18.92%)	30 (81.08%)	0.136
Duration of Symptoms (hrs)	≤24	04 (11.76%)	30 (88.24%)	06 (13.33%)	39 (86.67%)	0.836
	>24	01 (1.23%)	80 (98.77%)	07 (10.0%)	63 (90.0%)	0.017
BMI (Kg/m^2)	≤27	02 (3.85%)	50 (96.15%)	06 (11.76%)	45 (88.24%)	0.133
	>27	03 (4.76%)	60 (95.24%)	07 (10.94%)	57 (89.06%)	0.196

Table-III. Stratification of SSI according to age, gender, duration of symptoms and BMI of patients.

Outcome Variable	Group A (LA)	Group B (OA)	P-value	Interpretation
Surgical Site Infection (SSI)	5 (4.35%)	13 (11.3%)	0.049	Laparoscopic appendectomy (LA) was associated with significantly fewer SSIs if compared to open appendectomy (OA), indicating a lower infection risk with the minimally invasive approach.
Operative Time (minutes)	74±15	50.9±15	<0.001	LA had a significantly longer operative time than OA. This may reflect the technical complexity or setup time of laparoscopy.
Hospital Stay (days)	2.4±0.6	3.7±2.5	0.030	LA patients had a significantly shorter hospital stay, suggesting quicker postoperative recovery.
Return to Routine Activities (days)	14.4±3.1	18.1±3.3	<0.001	Patients in the LA group resumed routine activities significantly earlier than those in the OA group, further supporting faster functional recovery with laparoscopy.

Table-IV. Comparison of laparoscopic versus open appendectomy for perforated appendix

Effect Modifier	Findings	Interpretation
Age	SSI rates were lower in younger patients (15–35 years) in both groups. Among older patients (36–50 years), OA had a notably higher SSI rate (12.5%) compared to LA (2.13%) with a borderline significant p-value (0.050).	Older age appears to increase SSI risk, especially in the OA group. LA seems to offer more protective benefits in older patients.
Gender	SSI rates were higher in females than males in both groups, but differences were not statistically significant.	Gender does not significantly influence SSI rates, although a trend toward higher SSIs in females is observed.
Duration of Symptoms	For symptoms >24 hours, OA had significantly more SSIs (10%) vs LA (1.23%) with p = 0.017. No significant difference in those with symptoms ≤24 hours.	Longer symptom duration (>24 hours) increases SSI risk, particularly in OA. LA is significantly better in late presenters.
BMI	Higher BMI (>27) showed higher SSI rates in both groups, though differences were not statistically significant.	Elevated BMI trends toward increased SSI risk, but not significantly. LA may slightly reduce SSI risk in obese patients.

Table-V. Stratification of Surgical Site Infections (SSI) by age, gender, duration of symptoms, and BMI

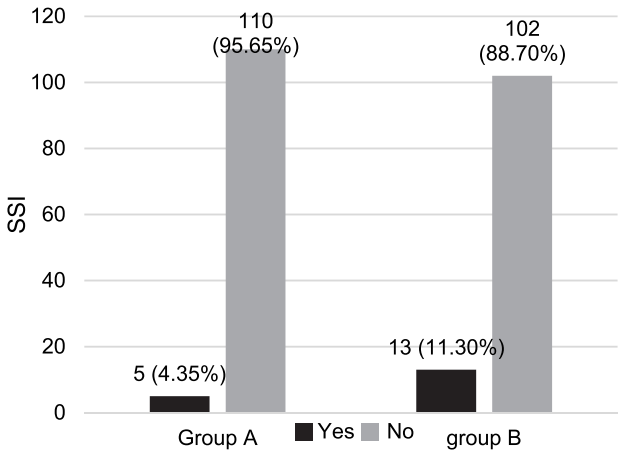

Figure-1. Comparison of the frequency of surgical site infection between laparoscopic versus open appendectomy for perforated appendix.

DISCUSSION

Appendicitis is the most common cause of surgical abdomen in all age groups. Approximately 7%–10% of the general population develops acute appendicitis, with the maximal incidence being in the second and third decades of life.[7] Laparoscopic appendectomy, unlike laparoscopic cholecystectomy, has not gained much popularity since its introduction. Despite numerous studies published to date comparing open appendectomy and laparoscopic appendectomy, the relative advantages of the two procedures are still debated.[8] It is argued that the advantages of LA over OA, such as short hospital stay, less analgesia requirement, rapid postoperative recovery, and better cosmetic outcome, are not significant.[9]

Our study demonstrated a significantly lower surgical site infection (SSI) rate in the laparoscopic appendectomy (LA) group (4.35%) compared to the open appendectomy (OA) group (11.30%). Our findings are in line with the established advantage of minimally invasive surgery in reducing wound complications. A higher risk of incisional infections and wound complications with open appendectomy is widely reported.[10] A meta-analysis by Quah et al. similarly reported complicated appendicitis (OR ≈0.26, p<0.001) wound infection rates of only ~4.7% after laparoscopic appendectomy versus 12.8% after open appendectomy[11], closely mirroring our findings. LA significantly lowers SSI risk in perforated appendicitis, as corroborated by several studies, both international and local. For example, a study by Nazir et al. at Holy Family Hospital, Rawalpindi, Pakistan, found wound infections to be 10.8% in LA versus 27.7% in OA (p=0.01).[12] Likewise, Arfat et al. reported SSIs in only 6.7% of laparoscopic SSIs compared to 30% in open surgery for perforated appendicitis (p<0.05).[13] These consistent findings underscore that the smaller incisions and reduced tissue exposure in laparoscopy translate into fewer superficial infections than the traditional open approach.

Furthermore, LA may also lessen the likelihood of other wound complications like dehiscence and hernias, in addition to lowering incisional SSI rates.[10] LA likely helps clear contamination more effectively due to the ease of lavage of the peritoneal cavity under direct camera vision, which likely leads to reduced infection risk.[12] It is worth mentioning that historically, there was concern that pneumoperitoneum or difficult irrigation in laparoscopic management of perforated appendicitis might increase intra-abdominal abscesses.[10] However, emerging evidence has addressed this concern: it has been seen that there is no significant difference in intra-abdominal abscess incidence between LA and OA when proper technique is used.[11,13] As discussed above, Arfat et al. observed similar intra-abdominal infection rates in both groups (~8–10%)[13], and similarly, Quah et al. reported an abscess rate of 6.1% in LA vs 4.6% in OA (OR 1.02, p=0.91).[11] Thus, our finding of reduced SSI with laparoscopic appendectomy is consistent with the findings in the broader literature, affirming that the laparoscopic approach for perforated appendicitis can enhance the quality of life of the patient by improving wound-related outcomes without increasing deep infections.

Considering the operative time, in our study, laparoscopic appendectomy required a longer operative time than open surgery (mean 74 ± 15 minutes vs 50.9 ± 15 minutes, p<0.0001). This difference of ~23 minutes reflects the added complexity of the minimally invasive technique

in this scenario, which often involves careful visualization, meticulous intracorporeal suturing or stapling of the appendiceal stump, and thorough peritoneal lavage through limited ports. These findings are consistent with other studies, which report LA to be more time-consuming. Horvath et al., a retrospective study, similarly reported that the LA technique for perforated appendicitis took slightly longer (mean ~64.5 min) than OA (~60 min, p=0.002).[14] The study at Combined Military Hospital, Abbottabad, Pakistan, by Arfat et al likewise noted a significantly longer mean operating time for LA (58.9 ± 5.4 min) compared to OA (49.7 ± 6.1 min).[13] The reasons for this time difference are: the need to establish pneumoperitoneum, trocar placement, and careful intra-abdominal dissection in purulent fields. Furthermore, instrument setup and the steep learning curve for advanced laparoscopic skills can prolong operative duration in laparoscopy, especially for complicated cases like this case, perforated appendicitis.

However, some disparity has been noted in operative time between laparoscopic and open techniques. Comparable or shorter operative times for laparoscopy have been reported by some studies. For example, a shorter mean operating time for LA (46.98 ± 2.99 min) than for OA (53.02 ± 2.88 min) (p<0.001) was paradoxically observed in perforated appendicitis by Nazir et al.[12] This finding suggests that, in a setting with experienced laparoscopic surgeons and proper training, the efficiency of the minimally invasive approach can match or exceed open surgery, and the time disparity can be overcome. This discrepancy in the research likely reflects variations in surgeon training, case selection, and intraoperative techniques. All in all, initial laparoscopic appendectomies tend to take longer, but as proficiency improves and experience is gained, the time gap narrows. Hence, our finding of a slightly longer operative time with LA is consistent with most published research, and this trade-off must be weighed against the clear postoperative benefits of laparoscopy.

In our study, the most evident advantage of laparoscopic appendectomy was the quicker postoperative recovery. Patients in the LA group had a significantly shorter hospital stay than those in the open group (mean 2.4 ± 0.6 days vs 3.7 ± 2.5 days, p=0.03). This approximately 1.3-day reduction in hospitalization is clinically meaningful and detrimental to patient quality of life and is consistent with the findings reported in prior studies on complicated cases of appendicitis. Minimally invasive surgery generally allows for faster mobilization, earlier return of bowel function, and less postoperative pain, facilitating earlier discharge. The meta-analysis by Quah et al. similarly found that patients with complicated appendicitis who underwent laparoscopic appendectomy had a mean hospital stay of 6.4 days versus 8.9 days for open appendectomy (MD ≈ –2.5 days, p=0.02).[11] Likewise, the systematic review by Athanasiou et al. noted significantly shorter inpatient stays after LA.[15] Similar to our settings, Rasuli et al. in Hyderabad, Pakistan, found a shorter length of hospitalization with LA as well (p<0.0001).[7] While one local RCT did not find a statistically significant difference (Nazir et al. reported ~4.4 days for LA vs 4.2 days for OA, p=0.23)[12] The trend even in that study did favour quicker discharge with laparoscopy. Our results add to the consensus that laparoscopic management of perforated appendicitis, probably by reducing the physiological stress and wound pain associated with a large incision, expedites recovery.

Other than exiting the hospital sooner, patients in the laparoscopic group of our study also returned to normal daily activities faster than those who had open surgery (approximately 14.4 ± 3.1 days vs 18.1 ± 3.3 days, p<0.0001). This nearly 4-day improvement in functional recovery is highly relevant for patient quality of life, as it implies an earlier return to work or school and resumption of routine tasks. International literature corroborates this advantage of LA. A comprehensive Cochrane review by Jaschinski et al noted that adults undergoing laparoscopic appendectomy returned to normal activities about 5 days sooner on average than those who had an open appendectomy.[16] Likewise, faster rehabilitation and earlier return to work with minimally invasive techniques have consistently been reported by

general surgery cohorts.[17]

Several factors contribute to faster recovery from surgery. Smaller wounds result in less postoperative pain, allowing patients to mobilize earlier. Additionally, reduced tissue trauma and inflammation accelerate the overall healing process. In our study of patients with perforated appendicitis, the laparoscopic approach enabled patients to recover more quickly, despite the severe initial pathology. This rapid recovery is particularly beneficial for young, working-age adults, with a mean age of approximately 35 years in our sample. Furthermore, in resource-limited settings, faster recovery is especially valuable, as prolonged hospital stays and downtime carry significant economic and social costs.

LIMITATIONS

This study has several limitations that should be considered. One major limitation is that it was conducted at a single tertiary care hospital, which may restrict the applicability of the findings to other settings, particularly rural hospitals with limited laparoscopic capabilities. Another limitation is the lack of blinding for surgeons and patients, which was unavoidable due to the nature of the intervention. This introduces a potential risk of performance and detection bias, such as differences in postoperative pain management or wound care protocols, which could have influenced the recovery outcomes.

CONCLUSION

Future studies and meta-analyses should confirm the benefits of laparoscopic appendectomy for perforated appendicitis, especially in children and the elderly. Research should focus on reducing operative time using advanced energy or suction devices. Economic analyses in low- and middle-income countries are needed, as shorter hospital stays may offset costs. Given its lower morbidity and faster recovery, laparoscopic appendectomy merits broader adoption.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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1	**Mudassar Jabeen:** Data analysis, paper writing, discussion writing.
2	**Zubia Noor:** Data collection, paper writing.
3	**Tayyab Riaz:** Review of the manuscript, data analysis.
4	**Shahbaz Ahmad:** Review of manuscript.
5	**Ghulam Mustafa:** Data collection.