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RETROSPECTIVE STUDY FOR ASSESSING OUTCOMES AND COST-EFFECTIVENESS IN OPEN VERSUS LAPAROSCOPIC APPENDECTOMY

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ABSTRACT

Introduction: *Acute appendicitis is one of the most common causes of acute abdominal pain. Both open appendectomy (OA) and laparoscopic appendectomy (LA) are widely performed; however, their relative outcomes remain debated, particularly in low-resource countries.*

Materials and methods: *This retrospective cohort study included 265 patients who underwent appendectomy between March 2023 and November 2024 at Narayani Central Hospital, Birgunj. Of these, 193 underwent OA and 72 underwent LA. Patients with conversion laparotomy, primary laparotomy, stump appendicitis, or pregnancy were excluded. Demographic data, operative time, hospital stay, cost, and complications were analyzed. Categorical variables were compared using the Chi-square or Fisher's exact test, and continuous variables were analyzed using the Mann–Whitney U test.*

Results: *Most patients were aged 10–19 years, with a male predominance (63%). The overall complication rate was significantly lower in the LA group than in the OA group (2.78% vs. 19.17%, p = 0.0008). The mean operative time was longer for LA (80.5 ± 21.9 min) than for OA (34.4 ± 11.8 min, p < 0.05). Median hospital stay was slightly shorter in the LA group (2.06 ± 0.29 days) than in the OA group (2.09 ± 0.42 days, p < 0.05). Mean hospital cost was higher for LA (NPR 42,819 ± 1,400) than for OA (NPR 41,981 ± 3,156, p < 0.05). Both the Hasson and Veress needle techniques were safe for pneumoperitoneum creation, with no port-site injuries reported.*

Conclusion: *Laparoscopic appendectomy is associated with fewer complications, a shorter hospital stay, and better cosmetic outcomes compared with open appendectomy, though it requires longer operative time and slightly higher cost. In low-HDI settings, OA remains a practical alternative; however, LA should be encouraged where surgical expertise and resources are available.*

Keywords: *Appendicitis, Laparoscopic Appendectomy, Open Appendectomy*

INTRODUCTION

Acute appendicitis (AA) is inflammation of the appendix and remains one of the most common cause of acute abdominal pain in all age groups.[1] The lifetime incidence of acute appendicitis in the general population is about 7-9 %.[2,3,4] Open appendectomy (OA), first described by McBurney in 1894, and has long been considered the gold standard treatment for AA. However, with advancements in technology and minimally invasive surgical techniques, laparoscopic appendectomy (LA) has become an increasingly preferred alternative. Several international studies have reported that LA offers advantages such as reduced postoperative pain, shorter hospital stay, and better cosmetic outcomes compared with OA.[3,5,6] Nevertheless, in cases of complicated appendicitis, LA has been associated with a higher incidence of intra-abdominal abscess formation.[7]

In recent years, several studies from South Asia have reported a gradual increase in the adoption of laparoscopic surgery, though its utilization in low- and middle-income countries, including Nepal, remains limited due to factors such as cost, availability of equipment, and training of surgical teams. A study from Nepal reported that OA continues to be more frequently performed than LA in many provincial and district-level hospitals, primarily because of economic constraints and limited laparoscopic infrastructure. This contrasts with data from high-income countries, where LA is now the standard approach for both uncomplicated and selected complicated cases.[8]

Despite the growing global evidence favoring LA, comparative data on outcomes of OA versus LA in Nepalese

hospitals are scarce, particularly from private tertiary centers serving both urban and semi-rural populations. There remains uncertainty regarding whether the benefits of LA demonstrated in well-resourced settings, translate effectively in low-HDI regions of Nepal.

Appendectomy remains one of the most commonly performed emergency surgical procedures worldwide. Although laparoscopic appendectomy (LA) has shown advantages such as reduced postoperative pain, faster recovery, and fewer wound complications, its feasibility and cost-effectiveness in low-resource settings like Nepal are still uncertain. Many hospitals in developing countries continue to rely on open appendectomy (OA) due to limited equipment, training, and economic constraints.

Therefore, this study was needed to compare the clinical outcomes, complications, and hospital costs between LA and OA in a tertiary care setting in Nepal. The findings aim to provide locally relevant evidence to guide surgical decision-making, promote safe adoption of minimally invasive techniques, and inform health policy in similar low-resource environments.

MATERIALS AND METHODS

This retrospective observational cohort study was conducted in the Department of Surgery at Narayani Central Hospital, Birgunj, Nepal, from 1 March 2023 and 30 November 2024, and included all patients who underwent appendectomy for acute appendicitis during this period. A tertiary-level referral hospital that serves patients from the Terai region and adjoining areas of India. Ethical approval was obtained from the Ethical Review Board (ERB) of the Nepal Health Research Council (NHRC), and patient confidentiality was strictly maintained.

Appendicitis cases were diagnosed by surgeons based on clinical evaluation, laboratory investigations, and radiological findings. All patients diagnosed with acute appendicitis and treated surgically by either open appendectomy (OA) or laparoscopic appendectomy (LA) were considered for inclusion. Patients were categorized into two groups based on the surgical approach:

- Group OA: Patients who underwent open appendectomy.
- Group LA: Patients who underwent laparoscopic appendectomy.

The choice of surgical technique was determined by the operating surgeon in consultation with the patient, taking into account clinical condition, and patient preference.

Inclusion criteria

- Patients of more than 10 year age groups and both sexes diagnosed with acute appendicitis
- Patients who underwent either open or laparoscopic appendectomy at Narayani Central Hospital within the study period.
- Availability of complete hospital records.

Exclusion criteria

- Patients in whom laparoscopic appendectomy was converted to laparotomy.
- Patients in whom appendectomy was associated with other surgical procedure
- Primary laparotomy cases for generalized peritonitis or other causes.
- Stump appendicitis or appendicitis during pregnancy.
- Patients with incomplete medical records or lost follow-up data.

Primary Endpoint:

- To compare the overall postoperative complication rate between laparoscopic appendectomy (LA) and open appendectomy (OA).

Secondary Endpoints:

- To compare operative time, duration of hospital stay, and total hospital cost between the two groups.
- To analyze types of complications (wound infection, intra-abdominal abscess, bleeding) by surgical approach.
- To evaluate differences in complication rates between Veress and Hasson techniques used for creating pneumoperitoneum in the LA subgroup.

Surgical technique

Open appendectomy

Open appendectomy was performed through a right lower quadrant (McBurney or Lanz) incision. The appendix was delivered, the mesoappendix was divided,

and the base of the appendix was ligated and excised. The stump was managed by simple ligation or inversion, depending on the surgeon's preference.

Laparoscopic appendectomy

Laparoscopic appendectomy was performed using three ports (one 10-mm umbilical and two 5-mm working ports).

- Creation of pneumoperitoneum: The Veress needle technique was used in most cases. The Hasson open technique was reserved for patients with a history of previous abdominal surgery.
- The mesoappendix was divided using bipolar cautery and scissors. The base of the appendix was ligated and divided.
- The peritoneal cavity was irrigated only in cases of pus or perforation.
- The appendix was retrieved using a specimen retrieval bag or through the 10-mm cannula.
- The 10-mm port site was closed in all hasson open technique cases; as well as in cases where a 10-mm port site was used for a retrieval bag during the Veress needle technique and 5-mm ports were not closed.

Postoperative management and follow up

All patients received intravenous fluids, antibiotics, and analgesics as per hospital protocol. Oral fluids were allowed 6 hours after surgery once bowel sounds returned. Patients were discharged when they tolerated oral intake and had adequate pain control with oral medications. Wound inspection was performed on the second postoperative day, and patients were followed up on the seventh postoperative day. Additional visits were scheduled for those who developed surgical site infections (SSI). Transportation costs for follow-up visits were not included in the total hospital cost.

Data collection

Data were extracted from hospital records and operative notes using a structured proforma that included:

- Demographic data: age, sex.
- Clinical data: diagnosis.
- Intraoperative data: operative time, surgical technique, complications.
- Postoperative data: complications, hospital stay, cost, and follow-up findings.

All data were entered and analyzed in Microsoft Excel before statistical processing.

Key variable

Variable	Definition
Operative Time	Duration (in minutes) from skin incision to final skin closure.
Hospital Stay	Number of days from day of surgery to discharge.
Complications	Any adverse event occurring intraoperative and within 30 days post-surgery, including vascular injury, visceral injury, wound infection, intra-abdominal abscess, or bleeding.
Wound infection	Presence of purulent discharge or erythema at the wound site, with or without positive culture, within 30 days.
Intra-abdominal Abscess	Ultrasonography- or CT-confirmed fluid collection requiring antibiotics or drainage.
Hospital Cost	Total hospital bill (including operation, anesthesia, investigation, drugs, hospital stay and dressing charge in follow up visit), recorded in Nepa-lese Rupees (NPR).

Statistical analysis

All data were analyzed using GNU PSPP version 3 (open-source equivalent of SPSS). Continuous variables, including operative time, hospital stay, and total hospital cost, were first assessed for normality using the Shapiro–Wilk test and visual inspection of histograms and Q–Q plots. Normally distributed variables were summarized as mean ± standard deviation (SD) and compared between the laparoscopic and open appendectomy groups using the independent samples t-test. Non-normally distributed variables were expressed as median and compared using the Mann–Whitney U test. Categorical variables were compared using the Chi-square test or Fisher's exact test where applicable. A p-value < 0.05 was considered statistically significant.

Bias and study limitation

To minimize potential bias, data were collected from consecutive appendicitis cases that met the inclusion criteria. However, as this was a retrospective cohort study, some degree of selection and information bias could not be completely eliminated. The choice between laparoscopic and open appendectomy was based on surgeon preference, clinical judgment and patient preference, which may have introduced selection bias. Efforts were made to ensure data accuracy by cross-verifying operative notes, postoperative records, and discharge summaries. Baseline differences such as patient age, comorbidities, and disease severity may have influenced postoperative outcomes independently of the

surgical approach. Surgeons' varying levels of expertise in laparoscopic techniques could also act as confounding factors.

RESULTS

A total of 265 patients underwent appendectomy during the study period, of which 193 (72.8%) underwent open appendectomy (OA) and 72 (27.2%) underwent laparoscopic appendectomy (LA). The baseline characteristics of both groups were comparable with respect to age, sex distribution, and preoperative diagnosis (Table 1). The majority of patients were within the 10–19-year age group, and the overall male-to-female ratio was 1.7:1.

Table 1: Demography

Group	N	Age mean (yrs)	Age SD (yrs)	Age 95% CI (yrs)	Male (n)	Female (n)
OPEN	193	25.8	12.9	(23.97 - 27.63)	125	68
LAPAROSCOPIC	72	27.56	9.19	(25.40 - 29.73)	42	30

Operative and postoperative outcome

The overall complication rate was 2.78 % in the LA group compared with 19.17 % in the OA group, representing a statistically significant difference (p = 0.0008). The mean operative time was significantly longer for LA (80.49 ± 21.95 min) than for OA (34.40 ± 11.79 min) p < 0.05. The mean hospital stay was slightly shorter following LA (2.06 ± 0.29 days) compared with OA (2.09 ± 0.42 days) p < 0.05. The mean hospital cost was marginally higher in the LA group (NPR 42819.44 ± 1399.96) than in the OA group (NPR 41980.93 ± 3155.98) p < 0.05. These comparisons are summarized in Table 2.

Table 2: Operative and postoperative outcome

Group	N	Operative time (min)	Hospital stay (days)	Hospital cost (NPR)	Complications (%)
OPEN	37	34.40 ± 11.79 (32.73-36.08)	2.09 ± 0.42 (2.03-2.15)	41980.93 ± 3155.98 (41532.86 - 42429.01)	37 (19.17%)
LAPAROSCOPIC	2	80.49 ± 21.95 (75.33 - 85.64)	2.06 ± 0.29 (1.99 - 2.12)	42819.44 ± 1399.96 (42490.47 - 43148.42)	2 (2.78%)

Complication

The distribution of specific postoperative complications is shown in Table 3. Wound infection was the most common complication, occurring in 18.7 % of OA patients and 1.4 % of LA patients (95 % CI for difference = 10.4 % – 24.9 %; p < 0.001). Intra-abdominal abscess occurred in one LA case (1.4 %) and in none of the OA cases (p = 0.24). Postoperative bleeding occurred in one OA case (0.5 %) and none in LA (p = 1.00). There was no vascular or visceral injury during procedure. Overall, total complications were markedly lower in the LA group (2.8 %) than in the OA group (19.2 %) (p = 0.0003).

Table 3: Specific postoperative complications

Complication type	OA (n=193)	LA (n= 72)	Rate (OA %)	Rate (LA %)	95% CI for differ-ence in rates (OA–LA)	Female (n)
Wound infection	36	1	18.7 %	1.4 %	10.4 % – 24.9 %	< 0.001
Intra-abdominal abscess	0	1	0 %	1.4 %	−0.4 % – 3.1 %	0.24
Postoperative bleeding	1	0	0.5 %	0 %	−0.5 % – 1.6 %	1.00
Total complications	37(19.2 %)	2 (2.8 %)	—	—	—	0.0003

Laparoscopic subgroup analysis

Within the LA group, 70 patients (97.2 %) underwent pneumoperitoneum creation by the Veress needle technique, while 2 patients (2.8 %) underwent the Hasson open technique. Complications were observed in 1 patient (1.4 %) in the Veress group and 1 patient (50.0 %) in the Hasson group. No primary trocar-related or port-placement injuries were recorded with either method. The difference in complication rates between Veress and Hasson techniques did not reach statistical significance (p = 0.31). Detailed subgroup results are summarized in Table 4.

Table 4: Laparoscopic subgroup analysis

Tech-nique	No	Comp No.	Sur-gery time mean	Sur-gery time SD	Surgery time CI	Cost-mean	Cost SD	Cost CI	Com-plica-tion
VERESS	70	1	81	21.84	(75.79 - 86.20)	42828.57	1419.03	(42490.21 - 43166.92)	1 (1.43%)
HASSON	2	1	62.5	24.74	(159.85 - 284.85)	42500	0	(42500.0 - 42500.0)	1 (50.0%)

DISCUSSION

The incidence of acute appendicitis peaks during the second decade of life and shows a male predominance, consistent with global epidemiological patterns.[9] Advances in diagnostic modalities—particularly the combination of clinical scoring systems and ultrasonography have improved diagnostic accuracy, reducing the incidence of negative appendectomie.[10,11] The dictum "when in doubt, get it out" is no longer considered acceptable in modern surgical practice.

In this study, laparoscopic appendectomy (LA) accounted

for 27% of cases, while open appendectomy (OA) remained the more common approach (73%), largely due to lower procedural costs. This distribution aligns with global trends showing higher uptake of LA in high-income countries (67.7%) and much lower adoption in low- and middle-income settings (8.1%).[12] Economic factors, limited laparoscopic infrastructure, and the availability of trained surgeons continue to influence this disparity in countries like Nepal.

Our study demonstrated a markedly lower overall complication rate following LA (2.78%) compared with OA (19.17%), which is consistent with previous research showing wound infection rates of 4% in LA and up to 18% in OA.[13,14] The smaller incision, reduced tissue trauma, and limited exposure of the infected appendix to the abdominal wall fascia are key contributors to the lower infection rates seen in LA.[15] In the present series, wound infection was the most common complication in both groups, while intra-abdominal abscess occurred exclusively in the LA group. This mirrors findings from large cohort studies that report a slightly increased risk of intra-abdominal abscess formation after LA for complicated appendicitis.[7,14,16] However, this risk can be mitigated through meticulous peritoneal lavage and use of retrieval bags.

In the subgroup analysis, the Veress needle technique demonstrated a lower rate of surgical site infection compared to the Hasson open technique, a finding supported by meta-analyses showing the Veress method to be equally safe and more efficient in patients without prior abdominal surgery.[17,18] Importantly, no trocar or visceral injuries were reported in either group, reinforcing the procedural safety of both entry techniques in experienced hands.

The mean operative time for LA (80.49 ± 21.95 min) was significantly longer than for OA (34.40 ± 11.79 min). Similar findings have been reported in most comparative studies.[14,19,20] Although a few studies such as Nazir et al. observed shorter operative durations for LA in perforated appendicitis[21] the majority attribute longer LA times to the learning curve, limited access to advanced instruments (energy devices, staplers, endoloops), and the need for setup of laparoscopic equipment. With greater experience and technological availability, operative time differences tend to narrow. Postoperative recovery parameters favor LA. Patients in the LA group had a marginally shorter hospital stay (2.06 ± 0.29 days) compared with those undergoing OA (2.09 ± 0.42 days), a finding in line with previous studies demonstrating faster convalescence, earlier return to oral intake, and lower analgesic requirements following laparoscopy.[14,22,23] Furthermore, patient satisfaction regarding cosmetic outcomes is notably higher after LA, with previous studies reporting up to 80% satisfaction compared with 40% for OA scars.[24]

The mean hospital cost was marginally higher in LA (NPR 42,819.44 ± 1,399.96) compared with OA (NPR 41,980.93 ± 3,155.98). Similar cost trends have been reported in other low-resource countries where equipment costs and maintenance contribute to higher direct expenses.[15] However, when indirect costs such as prolonged recovery, transportation for follow-up visits, and lost wages are considered, LA may be more cost-effective overall. A Nigerian multicenter study found LA to be only USD 14 more expensive than OA after adjustment for such variables.[25] In the Nepalese context, initial procedural costs remain a limiting factor, but expansion of laparoscopic infrastructure and training could enhance accessibility and cost-efficiency in the long term.

CONCLUSION

Laparoscopic appendectomy showed shorter hospital stay, reduced postoperative pain, and lower wound infection rates compared with open appendectomy, without a significant difference in overall complications. Both Veress and Hasson methods for pneumoperitoneum creation were found to be safe and effective when performed by experienced surgeons. Although laparoscopic surgery incurs higher immediate costs, its faster recovery and lower morbidity may yield long-term economic benefits, even in resource-limited settings such as Nepal.

Given the retrospective, single-center nature of this study, these findings should be interpreted with caution. Future prospective, multicenter studies with larger sample sizes are recommended to confirm these results and to further evaluate cost-effectiveness in similar healthcare contexts.

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CONFLICT OF INTEREST: None

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