



COMPARISON OF SIMPLE LIGATION AND STUMP INVAGINATION TECHNIQUES IN OPEN APPENDECTOMY FOR ACUTE APPENDICITIS: A PROSPECTIVE STUDY

General Surgery

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ABSTRACT

Background: Management of the appendiceal stump during open appendectomy remains controversial. Traditionally, stump invagination was preferred to reduce peritoneal contamination; however, simple ligation has gained acceptance because of its technical simplicity and shorter operative duration. **Aim:** The present study was conducted to compare postoperative outcomes between simple ligation and stump invagination in patients undergoing open appendectomy. **Materials and Methods:** A total of 80 patients with clinically and radiologically confirmed acute appendicitis undergoing open appendectomy were included. Patients were equally divided into two groups: simple ligation and stump invagination. Outcomes assessed included operative duration, postoperative hospital stay, and postoperative complications such as surgical site infection, postoperative ileus, intra-abdominal collection, stump leakage, and mortality. Statistical analysis was performed using the Chi-square test, with $p < 0.05$ considered statistically significant. **Results:** Baseline demographic and clinical characteristics were comparable between both groups. Mean operative time was significantly shorter in the simple ligation group (38.6 ± 6.4 minutes) compared with the stump invagination group (46.9 ± 7.2 minutes) ($p < 0.001$). Mean postoperative hospital stay showed no significant difference between the groups (3.4 ± 0.9 vs 3.6 ± 1.0 days; $p = 0.38$). Postoperative complications were infrequent and comparable. Surgical site infection occurred in 10% and 12.5% of patients in the simple ligation and invagination groups, respectively. No stump leakage or mortality was observed. **Conclusion:** Simple ligation and stump invagination demonstrated comparable safety and postoperative outcomes in open appendectomy for acute appendicitis. Simple ligation was associated with shorter operative duration and may be preferred because of its technical ease and efficiency.

KEYWORDS

Acute Appendicitis, Open Appendectomy, Appendiceal Stump, Simple Ligation, Stump Invagination, Postoperative Complications

INTRODUCTION

Acute appendicitis remains one of the leading causes of emergency abdominal surgery across the world.^{7,11} It commonly affects adolescents and young adults and usually presents with right iliac fossa pain, fever, anorexia, nausea, or vomiting. Delay in diagnosis or treatment may result in perforation and increased postoperative morbidity.

The underlying pathology generally begins with luminal obstruction of the appendix caused by fecoliths, lymphoid hyperplasia, or less commonly parasites.^{7,11} Progressive distension and vascular compromise promote bacterial proliferation and inflammation, which may eventually lead to gangrene or perforation if untreated.^{5,9}

Appendectomy continues to be the definitive treatment for acute appendicitis and may be performed by open or laparoscopic techniques.^{3,7} Regardless of the approach, appropriate closure of the appendiceal stump is essential to avoid complications such as stump leak, intra-abdominal collection, and postoperative infection.^{1,2}

Two conventional methods are commonly used for stump management in open appendectomy. The first is simple ligation using absorbable sutures, whereas the second involves invagination of the stump into the caecum.^{1,12} Stump invagination was historically advocated to decrease contamination of the peritoneal cavity. However, with improvements in operative technique, antibiotic therapy, and perioperative care, the routine need for invagination has been questioned.¹²

Simple ligation is technically easier, requires less tissue handling, and is associated with shorter operative duration in many studies.^{1,10} Nevertheless, opinions regarding the superiority of either technique remain variable, particularly in centres where open appendectomy is still frequently practiced. The present study was therefore undertaken to compare simple ligation and stump invagination with respect to operative findings and postoperative outcomes in patients undergoing open appendectomy.

AIMS AND OBJECTIVES

Aim- To assess postoperative outcomes and morbidity between simple ligation and invagination techniques in open appendectomy.

Objectives

- To compare the mean operative time between both techniques.
- To evaluate duration of hospital stay.
- To compare postoperative complications.

MATERIALS AND METHODS

Study Design- This is a prospective observational study of comparison of simple ligation and stump invagination techniques in open appendectomy for acute appendicitis.

Study Centre- The study was conducted at Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan, India.

Study Duration- Duration of study was over a 22-month period from November 2023 to August 2025.

Study Population- A total of 80 patients with clinically and radiologically confirmed acute appendicitis undergoing open appendectomy were included.

Sample Size- Eighty patients from study population were equally divided via randomization into two groups:
Group A: Simple ligation
Group B: Stump invagination.

Sample Size Calculation- The sample size was determined considering a 95% confidence level, 80% study power, and expected difference in operative outcomes between the two surgical techniques based on previous studies. The calculated minimum sample size was 40 patients per group. Hence, a total of 80 patients were enrolled and equally allocated into two groups.

Sample Technique- Simple random technique was used.

Ethical Consideration- The study protocol was reviewed and

approved by the Institutional Ethics Committee prior to commencement of data collection. All procedures were carried out in accordance with ethical standards for research involving human participants.

Informed Consent

Written informed consent was obtained from all participants after explaining the objectives, benefits, and possible complications of the study in their own language. Confidentiality of patient information was maintained throughout the study period.

Eligibility Criteria

Inclusion Criteria

- Patients aged more than 12 years and less than 70 years
- Patient with clinically and radiologically confirmed acute appendicitis
- Patients willing to participate and provide written informed consent for surgical intervention

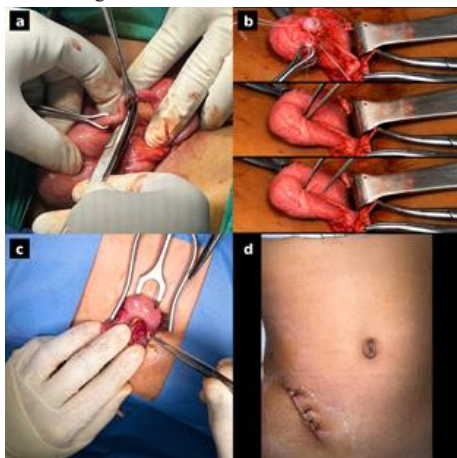


Fig 1: Operative images (a) Inflamed appendix in acute appendicitis, (b) Stump invagination technique, (c) Stump ligation technique and (d) Mcburney's incision

Exclusion Criteria

- Patients with associated pelvic pathology such as uterine or adnexal disorders, complicated appendicitis including appendicular mass, abscess, perforation, or caecal involvement.
- Patient being immunocompromised due to conditions such as HIV infection or ongoing immunosuppressive therapy.
- Patients who were deemed medically unfit for surgery because of significant comorbidities or those who declined operative management.

Study Procedures

Patients diagnosed with acute appendicitis [Fig 1(a)] and meeting the eligibility criteria underwent standardised preoperative evaluation. Initial assessment included routine haematological tests, renal function assessment, and coagulation studies. Ultrasonography of the abdomen was used as the primary imaging tool, while computed tomography was selectively employed in cases where clinical findings suggested complicated disease.⁸ Any existing medical conditions were addressed and stabilised prior to surgical intervention.

Assignment to the operative technique for appendiceal stump management was carried out using an alternate sequence method, resulting in two equal groups undergoing either simple ligation of the stump [Fig 1(c)] or burial of the stump by invagination [Fig 1(b)]. All surgeries were performed as open appendectomies through a right lower quadrant incision (McBurney's incision)[Fig 1(d)], with anaesthesia administered as either general or spinal based on patient assessment and anaesthetic discretion.¹¹

Postoperative care followed a uniform protocol. The operative site was first evaluated on the second day after surgery and subsequently reviewed at regular intervals. Patients were discharged once oral feeding was well tolerated and pain control was achievable with oral medications alone. Removal of skin sutures was performed on the tenth postoperative day. Follow-up evaluation was conducted at one month after surgery, during which patients underwent clinical assessment and additional investigations when clinically indicated.

Statistical Analysis

Collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 25.0. Quantitative variables were expressed as mean $\pm$ standard deviation, while qualitative variables were presented as frequencies and percentages. Continuous variables were compared using Student's unpaired t-test. Categorical variables were analyzed using Chi-square test or Fisher's exact test whenever appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

Eighty patients undergoing open appendectomy for acute appendicitis were included in the analysis. Patients were equally divided into two groups based on appendiceal stump management: Group A: Simple ligation (n = 40) and Group B Stump invagination (n = 40). Baseline demographic and clinical characteristics were comparable between the two groups.

Operative Time

The mean operative time was significantly shorter in the simple ligation group compared to the invagination group, reflecting the additional suturing steps required for stump burial.

Table 1: Comparison of Operative Time

Technique	Sample Size (n)	Mean Operative Time (min)	Standard Deviation	p-value
Group A (Simple ligation)	40	38.6	± 6.4	< 0.001
Group B (Stump invagination)	40	46.9	± 7.2	

Postoperative Hospital Stay

The duration of postoperative hospital stay was comparable between the two groups, with no statistically significant difference observed.

Table 2: Postoperative Hospital Stay

Technique	Sample Size (n)	Mean Hospital Stay (days)	Standard Deviation	p-value
Group A (Simple ligation)	40	3.4	± 0.9	0.38
Group B (Stump invagination)	40	3.6	± 1.0	

Postoperative Complications

Postoperative complications were infrequent and similarly distributed between the two groups. Surgical site infection was the most common complication observed. No cases of stump leakage, intra-abdominal abscess, caecal injury, or mortality were reported in either group.

Table 3: Postoperative Complications

Complication	Group A- Simple Ligation (n=40)	Group B- Invagination (n=40)	p-value
Surgical site infection	4 (10%)	5 (12.5%)	0.72
Postoperative ileus	2 (5%)	2 (5%)	1.00
Intra-abdominal collection	1 (2.5%)	1 (2.5%)	1.00
Stump leakage	0	0	—
Mortality	0	0	—

DISCUSSION

Management of the appendiceal stump during open appendectomy has long remained an area of surgical debate. The present study demonstrated that both simple ligation and stump invagination provided comparable postoperative outcomes in patients undergoing emergency appendectomy for acute appendicitis. No significant difference was identified in terms of postoperative morbidity or duration of hospitalisation.

One of the notable observations in this study was the shorter operative duration associated with simple ligation. As shown in Table 1, the additional suturing and manipulation required for stump burial increased operative time in the invagination group.^{10,1} In busy emergency settings, a technically simpler procedure that reduces

operating time without compromising patient safety may offer practical advantages.

The duration of postoperative hospital stay was similar in both groups.^{10,1} Recovery parameters such as oral intake, mobilisation, and pain control did not differ significantly, indicating that the method of stump closure had minimal impact on early postoperative recovery.

Postoperative complications were infrequent and comparable in both groups. Surgical site infection was the most common complication encountered, whereas serious adverse events such as stump leakage, faecal fistula, or mortality were absent.^{1,10} These findings support previous studies suggesting that routine stump invagination may not confer additional protection against postoperative complications.¹²

Historically, invagination was advocated to minimise peritoneal contamination and reduce the risk of stump-related infection. However, advances in antibiotics, operative asepsis, and perioperative care have substantially improved surgical outcomes, thereby reducing the necessity for additional stump burial procedures.^{7,8} Simple ligation avoids unnecessary tissue handling and is easier to perform, especially in inflamed tissues.

The findings of this study suggest that both techniques are safe and clinically effective. In institutions where open appendectomy continues to be routinely performed, selection of stump management technique may reasonably depend on surgeon preference, intraoperative findings, and available resources rather than expectation of major differences in outcome.

LIMITATIONS

The relatively short follow-up period of one month limited assessment of delayed complications such as adhesive intestinal obstruction or stump appendicitis. Future research with longer follow-up and adjustment for potential confounding variables, including BMI and appendiceal position, may provide more comprehensive evidence. Overall, both techniques demonstrated comparable outcomes, supporting their use according to operative preference and clinical setting. Overall, findings affirm both techniques equivalence, supporting surgeon discretion per context.

CONCLUSION

This prospective observational study comparing simple ligation and stump invagination during open appendectomy for acute appendicitis found no significant difference between the two techniques with regard to postoperative recovery, hospital stay, or complication rates. Major complications such as stump leakage, faecal fistula, and mortality were not encountered in either group.

Both techniques demonstrated satisfactory safety and effectiveness. Therefore, the choice of appendiceal stump management can be individualised according to surgeon experience, operative findings, and institutional practice, with emphasis on safe and efficient surgical care.^{1,10}

These findings indicate that both methods provide a similar level of safety and clinical effectiveness. Accordingly, the choice of appendiceal stump management may be guided by the surgeon's expertise, intraoperative considerations, and institutional practice patterns, with an emphasis on efficiency and optimal patient care rather than concern for differential outcomes.^{7,10}

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