

CUMULATIVE IMPLEMENTATION OF POSTOPERATIVE ENHANCED RECOVERY AFTER SURGERY (ERAS) ELEMENTS AND POSTOPERATIVE LENGTH OF STAY AFTER EMERGENCY LAPAROTOMY FOR PERFORATED APPENDICITIS: A RETROSPECTIVE ANALYTICAL CROSS-SECTIONAL STUDY IN AN INDONESIAN TERTIARY REFERRAL HOSPITAL

Kresna Ardinugraha Widayat^{1*}, Setyo Sugiharto², Solimun³

¹Surgical Resident, Specialist Education Programme in Surgery, Faculty of Medicine, Universitas Brawijaya – Dr. Saiful Anwar General Hospital, Malang, East Java, Indonesia | Email: kresna.widayat@gmail.com

²Division of Digestive Surgery, Department of Surgery, Faculty of Medicine, Universitas Brawijaya – Dr. Saiful Anwar General Hospital, Malang, East Java, Indonesia

³Universitas Brawijaya, Malang, East Java, Indonesia

*Corresponding Author: Kresna Ardinugraha Widayat, Department of Surgery, Faculty of Medicine, Universitas Brawijaya – Dr. Saiful Anwar General Hospital, Jl. Jaksa Agung Suprpto No. 2, Malang 65111, Indonesia | Email: kresna.widayat@gmail.com

ABSTRACT

Background: Perforated appendicitis often requires emergency laparotomy and prolongs hospitalisation. Enhanced Recovery After Surgery (ERAS) shortens stay in elective surgery, but appendectomy is excluded from ERAS Society emergency laparotomy guidelines, and evidence from low- and middle-income settings is limited. **Objective:** To describe the implementation of seven postoperative ERAS elements and to analyse the association between the number of elements implemented and postoperative length of stay (LOS) in adults undergoing emergency laparotomy for perforated appendicitis. **Methods:** Retrospective analytical cross-sectional study of medical records at Dr. Saiful Anwar General Hospital, Malang, Indonesia (2023–2025). Adults aged 18–59 years with clinically and intraoperatively confirmed perforated appendicitis were consecutively sampled. The exposure was the number (0–7) of elements implemented: antiemetic prophylaxis, opioid avoidance, early oral nutrition, early mobilisation, and early removal of nasogastric tube, drain and urinary catheter. Spearman's correlation was the primary analysis; adjusted analyses were exploratory. **Results:** Sixty patients were analysed (mean age 33.2 ± 11.5 years; 68.3% male; ASA III–IV 43.3%). Median postoperative LOS was 3 days (interquartile range [IQR] 3–5; mean 3.68 ± 1.66). Early nutrition (80.0%), nasogastric tube removal (76.7%) and mobilisation (75.0%) were most frequently implemented; early urinary catheter removal was least frequent (20.0%). No patient received all seven elements (median 4; IQR 3–5). The number of elements correlated inversely with LOS ($\rho = -0.455$; 95% CI -0.635 to -0.227 ; $p < 0.001$). The association persisted after adjustment for ASA class, age and sex (partial $\rho = -0.369$; $p = 0.005$); each additional element was associated with a 0.46-day shorter stay (95% CI 0.04–0.88). **Conclusion:** Greater cumulative implementation of postoperative ERAS elements was moderately associated with shorter postoperative stay after emergency laparotomy for perforated appendicitis. Early removal of urinary catheters and drains represents the principal opportunity for improvement, supporting a multidisciplinary, checklist-based emergency ERAS protocol.

Keywords: Perforated Appendicitis, Enhanced Recovery After Surgery, Emergency Laparotomy, Length of Stay, Guideline Adherence

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INTRODUCTION

Acute appendicitis is the most common abdominal surgical emergency worldwide, with an estimated global age-standardised incidence of approximately 230 per 100,000 population in 2019 and a burden that peaks in adolescence and early adulthood. The lifetime risk is approximately 8.6% in males and 6.7% in females, and accurate diagnosis, prompt intervention and appropriate perioperative management remain central to outcomes.^{1–3}

In Indonesia, the prevalence of acute appendicitis has been reported at approximately 24.9 cases per 10,000 population, one of the highest in Southeast Asia. Regional data from East Java documented 5,980 cases with 177 deaths in 2017, underscoring the persistent burden of the disease and its complications in the Indonesian health system.^{4,5}

Emergency laparotomy is performed in physiologically compromised patients and elicits a pronounced neurohumoral and inflammatory stress response characterised by catabolism, insulin resistance, muscle weakness and gastrointestinal dysfunction, all of which delay recovery. Complicated appendicitis is associated with an approximately six-fold

greater likelihood of hospitalisation beyond 72 hours, and pain duration, faecoliths, free fluid, operative time and delayed presentation are recognised determinants of prolonged stay after perforation.^{6–8}

Enhanced Recovery After Surgery (ERAS) is an evidence-based, multimodal and multidisciplinary perioperative pathway designed to attenuate the surgical stress response and accelerate functional recovery across the preoperative, intraoperative and postoperative periods. Originating in elective colorectal surgery, ERAS has been associated with reductions in complications, length of stay and costs across numerous specialties, and higher compliance with its elements has been associated with progressively better outcomes.^{9–12}

The ERAS Society published its first consensus guidelines for emergency laparotomy in two parts, addressing preoperative care in 2021 and intraoperative and postoperative care in 2023. These guidelines explicitly exclude appendectomy, cholecystectomy, trauma and vascular laparotomy. Meta-analyses of emergency abdominal surgery nevertheless suggest that ERAS-type pathways shorten time to oral intake

and hospital stay and reduce complications without increasing readmission or reoperation.^{13–15}

Against this background, the present study evaluated routine implementation of postoperative ERAS elements in adults with perforated appendicitis undergoing emergency laparotomy in an Indonesian tertiary referral and teaching hospital, where ERAS implementation in emergency surgery has not previously been documented.

A. Objectives of the Study

The general objective was to analyse the association between ERAS implementation and postoperative length of stay (LOS) in patients with perforated appendicitis undergoing emergency laparotomy at Dr. Saiful Anwar General Hospital, Malang. The specific objectives were (1) to identify which ERAS elements are routinely and which are not routinely implemented, and (2) to analyse the association between the number of ERAS elements implemented and postoperative LOS.

B. Research Hypothesis

Because the first specific objective was descriptive, no hypothesis was formulated for it. For the second objective, the research hypothesis (H₁) was that the number of ERAS elements implemented is inversely associated with postoperative LOS, whereas the null hypothesis (H₀) stated that no association exists.

C. Significance of the Study

Theoretically, this study extends the evidence base on ERAS in emergency surgery to perforated appendicitis, a population excluded from current emergency laparotomy guidelines. Clinically, it provides institution-specific data that may guide correct implementation of ERAS elements, inform a multidisciplinary emergency ERAS protocol, and thereby shorten the hospital stay of patients with perforated appendicitis.

LITERATURE REVIEW

A. Perforated Appendicitis: Diagnosis and Management

Diagnosis rests on history, physical examination, inflammatory markers, clinical scoring systems such as the Alvarado score and the Adult Appendicitis Score, and imaging, with ultrasonography and computed tomography used to differentiate uncomplicated from complicated disease. Perforation occurs in approximately one in five presentations and is characterised by severe abdominal pain, vomiting, fever above 38.5 °C and signs of diffuse peritonitis, occasionally with septic shock.^{16–21}

Scoring systems remain useful adjuncts to clinical assessment. The Alvarado score assigns points to eight clinical and laboratory features (Table 1), whereas the Adult Appendicitis Score incorporates graded tenderness, guarding, leucocyte count, neutrophil proportion and C-reactive protein stratified by symptom duration (Table 2); comparative studies suggest that the Adult Appendicitis Score is slightly more accurate.^{20,21}

Table 1. Alvarado Score²⁰

Component	Score
Migration of pain to the right lower quadrant	1
Anorexia	1
Nausea or vomiting	1
Right lower quadrant tenderness	2
Rebound tenderness	1
Temperature >37.3 °C	1
Leucocytosis >10,000/mm ³	2
Neutrophils >75%	1
Interpretation: 1–4, low; 5–6, intermediate; 7–10, high probability	

Table 2. Adult Appendicitis Score²⁰

Component	Score
Right lower quadrant pain	2
Pain relocation	2
Right lower quadrant tenderness	3
Guarding	Mild 2; moderate–severe 4
Leucocytes (×10 ⁹ /L)	7.2–<10.9: 1; 10.9–<14.0: 2; ≥14.0: 3
Neutrophils (%)	62–<75: 2; 75–<83: 3†; ≥83: 4
CRP (mg/L), symptoms <24 h	4–<11: 2; 11–<25: 3; 25–<83: 5; ≥83: 1
CRP (mg/L), symptoms ≥24 h	12–<53: 2; 53–<152: 2; ≥152: 1
Interpretation: 0–10, low; 11–15, intermediate; ≥16, high probability	

†Omitted in the source thesis table and completed according to the original score. CRP, C-reactive protein.

Appendicectomy remains the treatment of choice, and the laparoscopic approach is preferred because it reduces wound infection, analgesic requirement and postoperative stay. However, laparoscopic facilities remain limited in many low- and middle-income countries, and intraoperative findings such as periappendicular abscess and diffuse peritonitis frequently necessitate an open approach. In perforated appendicitis with generalised contamination, laparotomy permits appendicectomy together with peritoneal lavage and source control.^{2,8,22–24}

B. Enhanced Recovery After Surgery

The ERAS concept was introduced by Henrik Kehlet in 1997, who proposed that combining multiple evidence-based modifications of perioperative care could substantially improve outcomes. The ERAS Study Group was formed in 2001 and evolved into the ERAS Society in 2010, which develops GRADE-based guidelines, promotes structured multidisciplinary implementation and audits compliance, with greater compliance consistently associated with better outcomes.^{10,11}

The ERAS Society emergency laparotomy recommendations comprise preoperative, intraoperative and postoperative elements (Table 3). Postoperative nausea and vomiting delay discharge and increase costs, and are mitigated by combination antiemetic prophylaxis, regional techniques, opioid minimisation and euvoemia. Multimodal analgesia with paracetamol, non-steroidal anti-inflammatory drugs and regional anaesthesia limits opioid-related ileus. Early oral intake, early mobilisation and early removal of urinary catheters, drains and nasogastric tubes are core postoperative

elements that facilitate the return of gastrointestinal function and physical independence.^{13,14,25–28}

Table 3. ERAS Elements for Emergency Laparotomy^{13,14}

Preoperative	Intraoperative	Postoperative
Management of physiological derangement	Restricted use of drains†	Early urinary catheter removal†
Sepsis monitoring	Skin antisepsis	Early NGT removal†
Early imaging, surgery and source control	Rapid-sequence induction	Early postoperative nutrition†
Patient risk assessment	Depth-of-anaesthesia monitoring	Early mobilisation†
VTE risk assessment	PONV prevention†	
Analgesia before anaesthesia	Temperature management	
Glucose and electrolyte management	Ventilation management	
Patient and family education	Fluid and electrolyte replacement	
	Glucose management	
	Transfusion management	
	Multimodal analgesia, minimal opioids†	

†Elements assessed in the present study. NGT, nasogastric tube; PONV, postoperative nausea and vomiting; VTE, venous thromboembolism.

The theoretical framework of the present study is summarised in Figure 1. Perforation causes peritoneal contamination requiring emergency laparotomy, which induces surgical stress, pain, gastrointestinal dysfunction and impaired mobilisation that prolong hospital stay; ERAS elements act across the perioperative period to attenuate these effects.

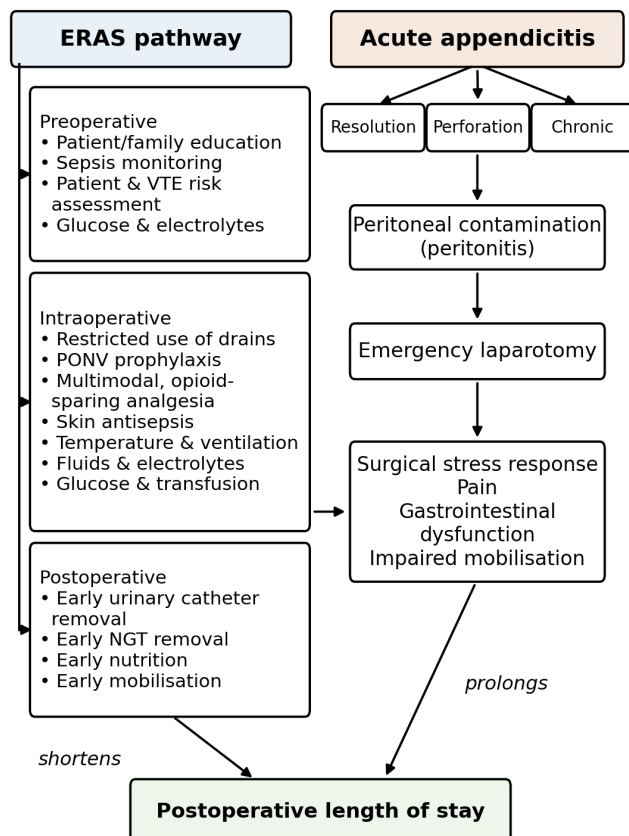


Figure 1: Theoretical framework. NGT, nasogastric tube; PONV, postoperative nausea and vomiting; VTE, venous thromboembolism.

C. Previous Studies

Evidence on ERAS in emergency abdominal surgery and appendicitis is summarised in Table 4. Randomised trials and meta-analyses generally report shorter hospitalisation without increased readmission, although not all trials have reached statistical significance and adherence to individual elements varies considerably in routine emergency practice.^{15,29}

Table 4. Summary of Previous Studies

Author (year)	Design; population	Main findings
Ruiz-Tovar et al. (2021) ³⁰	Prospective, 2 centres, Spain; 850 acute appendicitis	Full ERAS implementation 90.6% (86.8% complicated); CRP >13.5 mg/dL predicted incomplete implementation
Sharma et al. (2021) ³¹	RCT, India; 100 perforation/obstruction laparotomies	Median LOS 4 vs 7 days; fewer chest and wound infections
Pranavi et al. (2022) ³²	RCT, India; 120 perforation peritonitis	LOS 3 days shorter; faster bowel recovery; less PONV and SSI
Purushothaman et al. (2021) ³³	RCT, India; 60 trauma laparotomies	LOS 3.3 vs 5.0 days; earlier NGT, catheter and drain removal
Kumar et al. (2024) ³⁴	RCT, India; 60 perforation peritonitis	LOS 8.83 vs 12.23 days (p = 0.064, NS)
Cidoncha Secilla et al. (2024) ³⁵	Prospective vs historical cohort, Spain; 50 emergency appendicectomies	Postoperative stay 23 vs 38 h; no increase in morbidity
Ceresoli et al. (2023) ³⁶	Prospective multicentre; 589 emergency general surgery	Median adherence: NGT removal POD 1; mobilisation and catheter removal POD 2; oral intake POD 3; drains delayed recovery
Postigo-Morales et al. (2025) ³⁷	Prospective, Spain; 206 appendicectomy, cholecystectomy, perforated ulcer	Adherence >70% for most items; organisational barriers predominant
Hajibandeh et al. (2020) ¹⁵	Meta-analysis; 6 studies, 1,334 emergency abdominal surgery	Shorter LOS and fewer complications; similar mortality, readmission, reoperation
Sauro et al. (2024) ²⁹	Meta-analysis; 74 RCTs, 9,076 patients	LOS –1.88 days; fewer complications

CRP, C-reactive protein; LOS, length of stay; NGT, nasogastric tube; NS, not significant; POD, postoperative day; PONV, postoperative nausea and vomiting; RCT, randomised controlled trial; SSI, surgical site infection.

D. Research Gap

Several gaps therefore persist. First, perforated appendicitis managed by open laparotomy occupies an evidence gap between guidelines for uncomplicated appendicitis and ERAS recommendations for emergency laparotomy. Second, existing studies largely compare a complete protocol against conventional care and seldom quantify how many individual elements are actually delivered in routine practice. Third, data from Indonesian teaching hospitals, where care is delivered by rotating residents and ERAS implementation has not been formally documented, are scarce.^{13,14,30,38}

E. Novelty

The novelty of this study lies in its pragmatic, element-count approach: rather than dichotomising patients into protocol and non-protocol groups, it quantifies the real-world, cumulative delivery of seven postoperative ERAS elements in perforated appendicitis requiring open emergency laparotomy and relates this dose of adherence to postoperative stay in an Indonesian tertiary referral and teaching hospital. The analysis also identifies which individual elements are routinely delivered

and which lag behind, thereby generating locally actionable targets for protocol development.

METHODS

A. Research Design

This was an analytical observational study with a retrospective cross-sectional design using secondary data from medical records. The study was correlational, testing the association between the number of ERAS elements implemented and postoperative LOS, and is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cross-sectional studies.

B. Study Area

The study was conducted at Dr. Saiful Anwar General Hospital (RSUD Dr. Saiful Anwar), Malang, East Java, Indonesia, a provincial tertiary referral and teaching hospital affiliated with the Faculty of Medicine, Universitas Brawijaya. In this setting, perioperative care is delivered by surgical, anaesthesiology, nursing and nutrition teams together with specialist residents. Medical records from January 2023 to December 2025 were reviewed, and data collection and analysis were undertaken over a 12-month period.

C. Population, Eligibility and Sampling

The target population comprised patients diagnosed with perforated appendicitis at the study hospital. Inclusion criteria were (1) a medical record diagnosis of perforated appendicitis between 2023 and 2025; (2) age 18–59 years; (3) diagnosis established by clinical examination and confirmed by operative findings; and (4) emergency laparotomy. Exclusion criteria were psychiatric or neurological disease, septic shock, pregnancy, long-term corticosteroid use, non-operative management and incomplete medical records precluding ascertainment of the study variables.

Consecutive sampling was applied to all eligible medical records within the study period. Because the study was correlational, a minimum of 30 subjects was considered acceptable, and all eligible patients meeting the criteria were included up to the final sample. With 60 patients and a two-sided α of 0.05, the study had approximately 80% power to detect a correlation coefficient of $|\rho| \approx 0.36$ (Fisher z approximation). The selection process is shown in Figure 2.

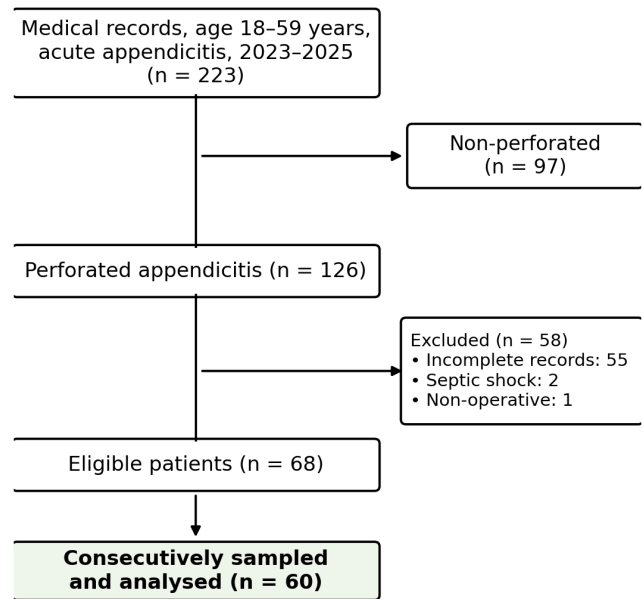


Figure 2: Flow diagram of patient selection.

D. Variables and Operational Definitions

The independent variable was the number of postoperative ERAS elements implemented per patient (discrete numerical scale, 0–7). Seven elements, selected from the ERAS Society emergency laparotomy recommendations (Table 3) because they were consistently documented in the medical records, were assessed: (1) antiemetic prophylaxis; (2) opioid avoidance (no opioid administered postoperatively); (3) early oral nutrition; (4) early mobilisation; (5) early removal of the nasogastric tube; (6) early removal of the abdominal drain; and (7) early removal of the urinary catheter. Nutrition and mobilisation were considered early when initiated on or before postoperative day (POD) 1; a tube, drain or catheter was considered early when it was not placed, was removed in the operating theatre, or was removed on or before POD 1. Each element scored 1 when implemented and 0 otherwise.

The dependent variable was postoperative length of stay (LOS), defined as the number of days from the day of surgery to hospital discharge. Covariates comprised age, sex and American Society of Anesthesiologists (ASA) physical status. Operational definitions are summarised in Table 5, and the conceptual framework is presented in Figure 3.

Table 5. Operational Definitions of Study Variables

Variable	Definition	Scale / unit
Perforated appendicitis	Specialist diagnosis from history, examination, investigations and operative findings	Nominal (1 = yes; 2 = no)
ERAS implementation	Number of the seven postoperative ERAS elements implemented (0–7)	Numerical; elements
Early nutrition / mobilisation	Initiated on the day of surgery or POD 1	Binary (1/0)
Early removal of NGT, drain, catheter	Not placed, removed in theatre, or removed on or before POD 1	Binary (1/0)
Antiemetic prophylaxis / opioid avoidance	Antiemetic given / no opioid given postoperatively	Binary (1/0)
Postoperative LOS	Days from surgery to discharge	Numerical; days

All variables were measured by medical record review. LOS, length of stay; NGT, nasogastric tube; POD, postoperative day.

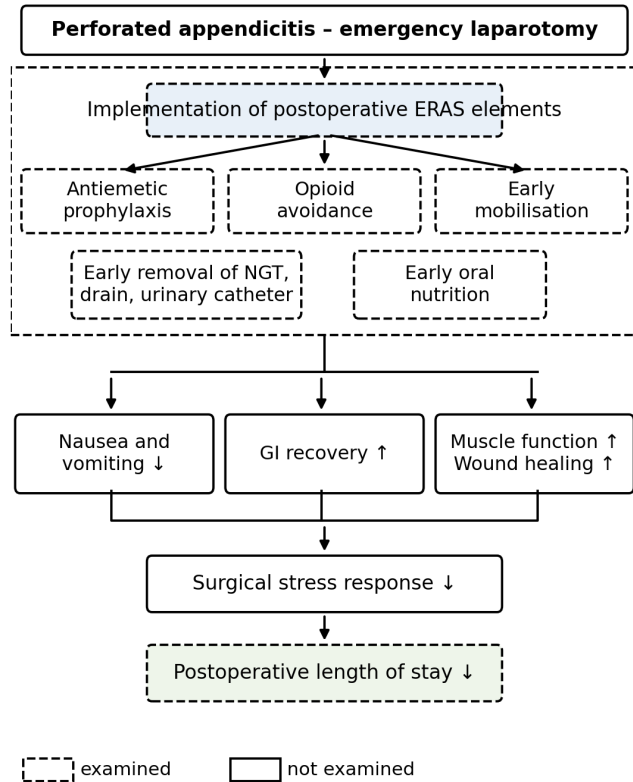


Figure 3: Conceptual framework. Dashed boxes, examined; solid boxes, not examined. GI, gastrointestinal; NGT, nasogastric tube.

E. Data Collection and Processing

After ethical clearance and institutional permission were obtained, medical records of patients with appendicitis were screened, eligible records were identified, and data were extracted using a standardised form. Data processing comprised editing (verification of accuracy and removal of records not meeting the criteria), coding, entry into Microsoft Excel, and cleaning to identify incomplete or inconsistent entries before analysis.

F. Statistical Analysis

Categorical variables are presented as frequencies and percentages and continuous variables as mean $\pm$ standard deviation (SD) and median with interquartile range (IQR). Normality was assessed with the Shapiro–Wilk test. Because both the number of ERAS elements and LOS were discrete and non-normally distributed, the primary analysis used Spearman's rank correlation coefficient (ρ), with the 95% confidence interval (CI) derived by Fisher's z transformation and verified by 5,000 bootstrap resamples. Pearson's product-moment correlation was calculated as a sensitivity analysis. Correlation strength was interpreted as weak (<0.30), moderate (0.30 – 0.59) or strong (≥ 0.60).

Exploratory analyses included (1) partial Spearman correlation adjusted for ASA class, age and sex; (2) multivariable linear regression of LOS on the number of elements, ASA class, age and sex with heteroscedasticity-consistent (HC3) standard errors; (3) comparison of LOS

across implementation strata (0–3, 4 and 5–6 elements) using the Kruskal–Wallis test with Kendall's τ -b for trend; (4) comparison of LOS according to implementation of each element using the Mann–Whitney U test, with a Bonferroni-corrected threshold of $p < 0.007$ for seven comparisons; and (5) a sensitivity analysis excluding records with duplicated medical record numbers. The primary analysis was performed in SPSS; the exploratory analyses were reproduced and extended in Python (SciPy and statsmodels). A two-sided $p < 0.05$ was considered statistically significant.

G. Ethical Considerations

The study protocol was approved by the Health Research Ethics Committee of Dr. Saiful Anwar General Hospital, Malang (ethical approval No. 400/238/K.3/102.7/2025, dated 12 August 2025). Only routinely collected medical record data were used; patient identities were anonymised by the use of study codes, and confidentiality was maintained in accordance with the approved protocol.

RESULTS

A. Study population

Of 223 medical records of patients aged 18–59 years with acute appendicitis, 97 were non-perforated and 126 had perforated appendicitis. Fifty-eight were excluded (incomplete records, $n = 55$; septic shock, $n = 2$; non-operative management, $n = 1$), leaving 68 eligible patients, of whom 60 were consecutively sampled and analysed (Figure 2).

The mean age was 33.2 ± 11.5 years (median 31; IQR 23–41), and nearly half of the patients (46.7%) were aged 18–29 years. Males predominated (41/60; 68.3%). ASA class I, II, III and IV were recorded in 28.3%, 28.3%, 35.0% and 8.3% of patients, respectively (Table 6).

B. Postoperative length of stay

The mean postoperative LOS was 3.68 ± 1.66 days (median 3; IQR 3–5; range 1–8). The most frequent LOS was 3 days (35.0%), whereas 4 patients (6.7%) stayed 8 days; 25 patients (41.7%) stayed longer than 3 days (Table 6). LOS was not normally distributed (Shapiro–Wilk $W = 0.858$; $p < 0.001$). LOS correlated positively with ASA class ($\rho = 0.358$; $p = 0.005$), was weakly and non-significantly correlated with age ($\rho = 0.231$; $p = 0.075$), and did not differ by sex (3.78 ± 1.72 vs 3.47 ± 1.54 days; $p = 0.486$).

Table 6. Characteristics of the Study Subjects ($n = 60$)

Variable	n	%
Age (years): mean $\pm$ SD 33.2 $\pm$ 11.5; median (IQR) 31 (23–41)		
18–29	28	46.7
30–39	16	26.7
40–49	9	15.0
50–59	7	11.7
Sex		
Male	41	68.3
Female	19	31.7
ASA physical status		
I	17	28.3

Variable	n	%
II	17	28.3
III	21	35.0
IV	5	8.3
Postoperative LOS (days): mean $\pm$ SD 3.68 $\pm$ 1.66; median (IQR) 3 (3–5)		
1	1	1.7
2	13	21.7
3	21	35.0
4	9	15.0
5	10	16.7
6	1	1.7
7	1	1.7
8	4	6.7

ASA, American Society of Anesthesiologists; IQR, interquartile range; LOS, length of stay; SD, standard deviation.

C. Implementation of postoperative ERAS elements

Implementation rates of the seven elements are shown in Table 7. Implementation was high ($\geq 75\%$) for early oral nutrition (48/60; 80.0%), early nasogastric tube removal (46/60; 76.7%) and early mobilisation (45/60; 75.0%); moderate (45–55%) for antiemetic prophylaxis (32/60; 53.3%), opioid avoidance (32/60; 53.3%) and early drain removal (27/60; 45.0%); and low for early urinary catheter removal (12/60; 20.0%). Oral nutrition was commenced on the day of surgery in 9 patients and on POD 1 in 39, and mobilisation on the day of surgery in 16 and on POD 1 in 29. No nasogastric tube was retained postoperatively in 37 patients and no drain in 23. Antiemetic prophylaxis consisted of metoclopramide in 30 patients and ondansetron in 2. Postoperative opioids (morphine, $n = 14$; fentanyl, $n = 14$) were administered to 28 patients, whereas non-opioid analgesia, predominantly metamizole-based, was given to 59 of 60 patients (98.3%).

The median number of elements implemented was 4 (IQR 3–5; mean 4.03 ± 1.31). One patient (1.7%) received none of the elements, the maximum achieved was six elements (9 patients; 15.0%), and no patient received all seven (Table 8).

Table 7. Implementation of Postoperative ERAS Elements (n = 60)

ERAS element	n	%	Level
Early oral nutrition	48	80.0	High
Early NGT removal	46	76.7	High
Early mobilisation	45	75.0	High
Antiemetic prophylaxis	32	53.3	Moderate
Opioid avoidance	32	53.3	Moderate
Early drain removal	27	45.0	Moderate
Early urinary catheter removal	12	20.0	Low

Level: high $\geq 75\%$; moderate 45–55%; low $< 25\%$. NGT, nasogastric tube.

Table 8. Number of ERAS Elements Implemented and Postoperative LOS

Elements	n (%)	Mean $\pm$ SD (days)	Median (IQR) (days)
0	1 (1.7)	4.0	4
1	1 (1.7)	3.0	3
2	4 (6.7)	6.0 $\pm$ 2.4	6.5 (4.5–8.0)

Elements	n (%)	Mean $\pm$ SD (days)	Median (IQR) (days)
3	13 (21.7)	4.5 $\pm$ 1.7	4 (3–5)
4	20 (33.3)	3.4 $\pm$ 1.6	3 (2–4.25)
5	12 (20.0)	3.6 $\pm$ 0.8	3 (3–4)
6	9 (15.0)	2.2 $\pm$ 0.7	2 (2–3)
7	0 (0)	–	–
Spearman $\rho = -0.455$ (95% CI -0.635 to -0.227); $p < 0.001$			

CI, confidence interval; IQR, interquartile range; LOS, length of stay; SD, standard deviation.

D. Association between the number of ERAS elements and length of stay

The number of ERAS elements implemented was inversely and moderately correlated with postoperative LOS (Spearman $\rho = -0.455$; 95% CI -0.635 to -0.227 ; bootstrap 95% CI -0.629 to -0.252 ; $p < 0.001$), supporting the research hypothesis. Pearson's correlation yielded a concordant estimate ($r = -0.437$; 95% CI -0.622 to -0.206 ; $p < 0.001$). Mean LOS declined from 6.0 ± 2.4 days with two elements and 4.5 ± 1.7 days with three elements to 3.4 ± 1.6 , 3.6 ± 0.8 and 2.2 ± 0.7 days with four, five and six elements, respectively (Table 8; Figure 4). In unadjusted linear regression, each additional element was associated with a 0.55-day shorter LOS (95% CI 0.25–0.85; $R^2 = 0.19$).

When patients were stratified by implementation level, LOS was 4.7 ± 1.9 days (median 4; IQR 3–5.5) with 0–3 elements ($n = 19$), 3.4 ± 1.6 days (median 3; IQR 2–4.25) with four elements ($n = 20$) and 3.0 ± 1.0 days (median 3; IQR 2–3) with 5–6 elements ($n = 21$), with a significant difference across strata (Kruskal–Wallis $p = 0.004$) and a monotonic trend (Kendall τ -b = -0.333 ; $p = 0.003$).

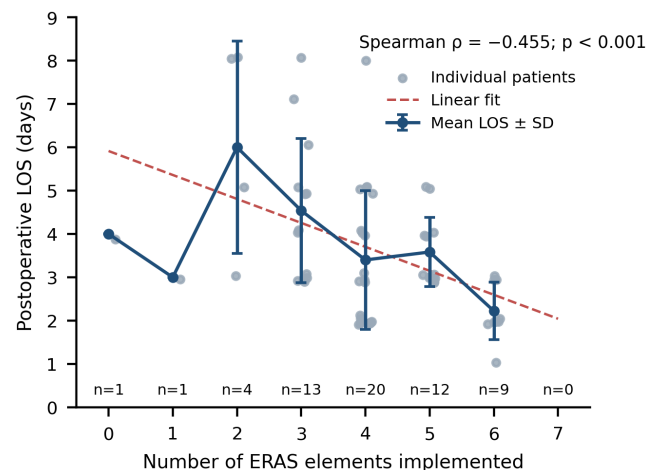


Figure 4: Postoperative LOS by number of ERAS elements implemented (mean $\pm$ SD; grey points, individual patients jittered for visibility; dashed line, linear fit).

E. Exploratory adjusted and component-level analyses

The number of elements implemented was lower in patients with higher ASA class ($\rho = -0.491$; $p < 0.001$). After adjustment for ASA class, age and sex, the inverse association persisted (partial $\rho = -0.369$; $p = 0.005$). In multivariable linear regression with robust standard errors, each additional element was independently associated with a 0.46-day shorter

LOS ($\beta = -0.46$; 95% CI -0.88 to -0.04 ; $p = 0.033$), whereas ASA class, age and sex were not independently significant (adjusted $R^2 = 0.21$) (Table 9).

At the component level, early nasogastric tube removal (3.3 ± 1.3 vs 5.0 ± 2.0 days; $p = 0.003$), early mobilisation (3.4 ± 1.6 vs 4.5 ± 1.6 days; $p = 0.007$) and early urinary catheter removal (2.6 ± 0.8 vs 4.0 ± 1.7 days; $p = 0.007$) were associated with shorter LOS and remained significant after Bonferroni correction. Early nutrition and early drain removal showed non-significant trends towards shorter stay, whereas antiemetic prophylaxis and opioid avoidance showed no association (Table 10).

The medical record dataset contained two duplicated medical record numbers (one identical duplicate and one duplicate with discordant element counts). Excluding all three affected rows ($n = 57$) did not materially change the primary estimate ($\rho = -0.469$; $p < 0.001$; Pearson $r = -0.446$; $p < 0.001$).

Table 9. Multivariable Linear Regression of Postoperative LOS

Variable	β (days)	95% CI	p
ERAS elements (per element)	-0.46	-0.88 to -0.04	0.033
ASA class (per class)	0.26	-0.19 to 0.72	0.260
Age (per year)	0.02	-0.02 to 0.06	0.248
Male sex	0.39	-0.54 to 1.32	0.413
$R^2 = 0.264$; adjusted $R^2 = 0.210$; partial Spearman $\rho = -0.369$, $p = 0.005$			

Ordinary least squares with HC3 robust standard errors (exploratory). ASA, American Society of Anesthesiologists; CI, confidence interval.

Table 10. Postoperative LOS by Implementation of Individual ERAS Elements

ERAS element	Implemented: n; mean $\pm$ SD; median (IQR)	Not implemented: n; mean $\pm$ SD; median (IQR)	p*
Early oral nutrition	48; 3.5 ± 1.5 ; 3 (2–4.25)	12; 4.5 ± 2.1 ; 4 (3–5.5)	0.109
Early NGT removal	46; 3.3 ± 1.3 ; 3 (2–4)	14; 5.0 ± 2.0 ; 5 (3–6.5)	0.003†
Early mobilisation	45; 3.4 ± 1.6 ; 3 (2–4)	15; 4.5 ± 1.6 ; 4 (3–5)	0.007†
Antiemetic prophylaxis	32; 3.6 ± 1.3 ; 3 (3–5)	28; 3.8 ± 2.0 ; 3 (2–4.25)	0.630
Opioid avoidance	32; 4.0 ± 2.0 ; 3 (3–5)	28; 3.4 ± 1.2 ; 3 (2.75–4)	0.516
Early drain removal	27; 3.4 ± 1.6 ; 3 (2–4)	33; 3.9 ± 1.7 ; 3 (3–5)	0.123
Early urinary catheter removal	12; 2.6 ± 0.8 ; 3 (2–3)	48; 4.0 ± 1.7 ; 3.5 (3–5)	0.007†

*Mann-Whitney U test. †Significant after Bonferroni correction ($p < 0.007$). LOS in days. IQR, interquartile range; NGT, nasogastric tube; SD, standard deviation.

DISCUSSION

This study found that, among adults undergoing emergency laparotomy for perforated appendicitis at an Indonesian tertiary teaching hospital, a greater number of implemented postoperative ERAS elements was moderately associated with a shorter postoperative stay. The association was graded, persisted after adjustment for physiological status, age and sex, and was robust to exclusion of duplicated records. Implementation was uneven: nutrition, nasogastric tube removal and mobilisation were delivered early in most patients, whereas early removal of urinary catheters and drains lagged considerably, and no patient received all seven elements.

The observed pattern of adherence broadly mirrors that of other emergency surgery cohorts. In a prospective multicentre study of 589 patients undergoing emergency general surgery for intra-abdominal infection or obstruction, median adherence was achieved on POD 1 for nasogastric tube removal, POD 2 for mobilisation and urinary catheter removal, and POD 3 for oral intake, and the presence of a drain was independently associated with delayed recovery. In a prospective Spanish study of emergency appendicectomy, cholecystectomy and perforated peptic ulcer, adherence exceeded 70% for most items but varied most for case-dependent measures such as drains and tubes, with organisational barriers predominating.^{36,37}

Adherence in the present cohort was, however, lower than in dedicated appendicitis programmes. In 850 patients with acute appendicitis managed within an ERAS protocol at two Spanish university hospitals, all protocol items were implemented in 90.6% of patients overall and in 86.8% of those with complicated appendicitis, and a preoperative C-reactive protein above 13.5 mg/dL predicted failure to complete the protocol. These data indicate that full implementation is achievable even in complicated disease when a formal protocol is in place, and that the incomplete adherence observed here reflects organisational rather than intrinsic patient barriers.³⁰

The low rate of early urinary catheter and drain removal deserves particular attention. The ERAS Society emergency laparotomy guidelines recommend urinary catheterisation only when hourly urine output and fluid balance must be monitored, typically during the first postoperative day, and early removal because catheters impede mobilisation, predispose to urinary tract infection and prolong stay; routine prophylactic drains are likewise not supported. The WSES guidelines advise against drains after appendicectomy for complicated appendicitis in adults, as they neither reduce surgical site infection nor intra-abdominal abscess and may prolong hospitalisation.^{14,22,23}

In our institution, many catheters and drains were removed only on the day before or the day of discharge. This practice probably reflects passive, habit-driven decision-making by nursing staff and residents, uncertainty about readiness for removal, and the tendency to defer catheter removal until the patient is fully mobile. Barriers to ERAS implementation are commonly classified as clinician-related (variable knowledge and inter-professional differences), facility-related (limited resources and long waiting times) and patient-related (comorbidity, education and culture). In a teaching hospital where perioperative care is delivered by rotating residents across surgery, anaesthesia, nutrition and nursing, such heterogeneity is magnified.^{11,38}

The inverse association between cumulative ERAS implementation and LOS is consistent with the broader literature. Meta-analyses of emergency abdominal surgery have reported shorter hospital stays and fewer complications with ERAS without increased readmission or reoperation, and a meta-analysis of 74 randomised trials across surgical specialties reported a mean reduction in LOS of 1.88 days.

Randomised trials in emergency laparotomy for intestinal perforation and obstruction, perforation peritonitis and abdominal trauma have similarly shown shorter hospitalisation with adapted ERAS pathways.^{15,29,31–33}

Not all trials have been positive. In a randomised study of 60 patients with perforation peritonitis, a modified ERAS protocol produced a shorter but statistically non-significant LOS (8.83 vs 12.23 days; $p = 0.064$), and the authors emphasised that not every element can be applied in the emergency setting. Conversely, a prospective fast-track pathway for emergency appendectomy reduced mean postoperative stay from 38 to 23 hours without increasing morbidity. Our element-count approach complements these comparative designs by demonstrating a dose–response pattern within routine care, in keeping with observations that LOS falls in proportion to the number of ERAS elements implemented and that adherence to early mobilisation, catheter removal and feeding is associated with shorter stay even in low-resource environments.^{34,35,39,40}

Several mechanisms may explain these findings, and the elements act synergistically. Adequate multimodal, opioid-sparing analgesia permits earlier mobilisation and reduces opioid-related ileus and nausea, while antiemetic prophylaxis reduces postoperative nausea and vomiting, which otherwise delays discharge and increases costs. Tubes, drains and catheters cause discomfort and pain, discourage ambulation and oral intake, and their early removal facilitates mobilisation.^{25–28}

Early oral nutrition counteracts postoperative hypermetabolism, catabolism and insulin resistance, supports protein anabolism, muscle preservation and wound healing, and stimulates intestinal motility; a meta-analysis of randomised trials showed that early oral feeding after gastrointestinal surgery shortens time to flatus and stool, reduces complications and may shorten stay. Early mobilisation improves ventilation, airway clearance and cough effectiveness, stimulates gut motility and mitigates insulin resistance and muscle loss. Prolonged nasogastric decompression impairs cough, swallowing and secretion clearance and discourages eating and ambulation; although early oral feeding modestly increases the risk of nasogastric tube reinsertion, it remains associated with shorter stay and fewer complications.^{30,41–43}

At the component level, early nasogastric tube removal, early mobilisation and early urinary catheter removal were each associated with shorter stay. These findings should be interpreted cautiously. Antiemetic prophylaxis and opioid avoidance were not associated with LOS, possibly because antiemetics may have been prescribed preferentially to symptomatic patients and because opioid use may have reflected greater pain from more severe peritonitis. More importantly, the elements most strongly associated with discharge are also markers of clinical progress, so that reverse causation—patients who recover well being more readily mobilised and freed from tubes—cannot be excluded.

The ERAS Society guidelines for emergency laparotomy exclude appendectomy, yet perforated appendicitis managed by open laparotomy shares the key pathophysiological features of emergency laparotomy: peritoneal contamination, systemic inflammation and postoperative ileus. Our findings therefore support adapting the postoperative elements of these guidelines to this population. We propose an institutional, procedure-specific emergency ERAS protocol—for example for peritonitis and for bowel obstruction—operationalised as a mandatory multidisciplinary checklist that assigns responsibility for each element. Examples include removal of the urinary catheter in the operating theatre or within 24 hours unless hourly urine output monitoring is required, avoidance of routine drains, and nurse-led early feeding and mobilisation targets.^{6,13,14}

LIMITATIONS AND FUTURE WORK

This study has several limitations. First, only seven postoperative elements could be analysed because many preoperative and intraoperative elements—rapid-sequence induction, depth-of-anaesthesia monitoring, temperature, ventilation and fluid management, and identification of physiological derangement—were inconsistently documented and lie largely within the domain of anaesthesiology. Second, the retrospective cross-sectional design precludes causal inference and is vulnerable to confounding by indication and reverse causation; although the association persisted after adjustment for ASA class, residual confounding by peritonitis severity, inflammatory markers, operative duration and postoperative complications, which were not captured, is likely. Third, the element count assumes equal weighting of heterogeneous interventions. Fourth, the exclusion of 55 patients with incomplete records may have introduced selection bias, and the reason for sampling 60 of 68 eligible patients was not recorded. Fifth, the single-centre setting, restriction to patients aged 18–59 years and exclusion of septic shock limit generalisability. Finally, complications, readmission and mortality were not assessed, so the safety of earlier discharge cannot be inferred.

Despite these limitations, the study provides the first institutional documentation of ERAS implementation in perforated appendicitis requiring emergency laparotomy in this setting, uses the complete eligible consecutive sample, and demonstrates a consistent association across primary, sensitivity and adjusted analyses. Prospective multidisciplinary studies involving anaesthesiology, nursing and nutrition teams, recording pre-, intra- and postoperative elements together with complications and readmissions, are required to confirm these findings and to define which elements confer the greatest benefit.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Among adults undergoing emergency laparotomy for perforated appendicitis at Dr. Saiful Anwar General Hospital, early oral nutrition, early nasogastric tube removal and early mobilisation were routinely implemented, whereas early

urinary catheter removal and early drain removal were the least implemented ERAS elements. The number of postoperative ERAS elements implemented was moderately and inversely associated with postoperative length of stay: the more elements implemented, the shorter the hospital stay.

Recommendations

1. A multidisciplinary emergency ERAS guideline involving surgery, anaesthesiology, nursing and clinical nutrition should be developed and enforced through a standardised checklist, with explicit targets for early removal of urinary catheters, drains and nasogastric tubes, early feeding and early mobilisation.

2. Medical record documentation of perioperative care should be standardised so that preoperative, intraoperative and postoperative ERAS elements can be audited continuously.

3. Further research should include pre- and intraoperative elements in collaboration with other disciplines and should adopt prospective designs that evaluate ERAS implementation directly, together with complications, readmission and patient-reported outcomes.

DECLARATIONS

Ethics approval: Health Research Ethics Committee of Dr. Saiful Anwar General Hospital, Malang (No. 400/238/K.3/102.7/2025; 12 August 2025).

Author contributions: KAW: conceptualisation, data collection, analysis and drafting; SS: supervision, clinical interpretation and critical revision; S: methodology, statistical analysis and critical revision. All authors approved the final manuscript.

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