

Predicting Mortality and Length of Stay After Laparotomy for Intra-Abdominal Infection: The Role of Physical Examination and Antimicrobial Susceptibility

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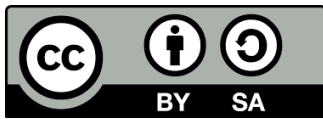
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Abstract

Intra-abdominal infection (IAI) is a surgical emergency associated with high mortality and poor clinical outcomes. This study aimed to analyze the associations of abdominal physical examination findings, vital signs, and antimicrobial susceptibility with clinical outcomes, specifically mortality and length of stay (LOS), in patients undergoing laparotomy for IAI. This retrospective observational cohort study included 60 patients with IAI treated at RSUD Dr. R. Soedjati Soemodardjo Purwodadi Grobogan between January 2024 and December 2025. Data were extracted from medical records and analyzed using univariate, bivariate, and multivariable analyses, with statistical significance set at $p < 0.05$. The mortality rate was 26.7%, and the median LOS was 6 days. Bivariate analysis showed that abdominal distension, mean arterial pressure (MAP), heart rate, respiratory rate, body temperature, and oxygen saturation were significantly associated with mortality ($p < 0.05$). MAP and body temperature were also significantly associated with LOS. Abdominal guarding and extended-spectrum beta-lactamase (ESBL) status were not significantly associated with either clinical outcome. In the multivariable analysis, preoperative length of stay emerged as an independent predictor of prolonged LOS ($p < 0.001$), whereas no independent predictor of mortality was identified. Physical examination findings, particularly abdominal distension, together with vital signs, were important early clinical parameters associated with mortality and LOS in patients undergoing laparotomy for IAI.



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INTRODUCTION

Intra-abdominal infection (IAI), including peritonitis, is a surgical emergency caused by the invasion of pathogenic microorganisms into the abdominal cavity (Brunicardi et al., 2019). This condition is associated with high mortality and poor clinical outcomes (Puspitadewi et al., 2018). Management of IAI generally requires surgical source control combined with appropriate antimicrobial therapy (Pangalila et al., 2024). The prevalence of peritonitis in Indonesia in 2018 was estimated at approximately 150,000 cases annually (Kartiwa et al., 2024). In Central Java, 5,980 cases of peritonitis were reported in 2018, resulting in 177 deaths (Puspitadewi et al., 2018). Clinical outcomes in patients with peritonitis, including mortality and length of stay (LOS), may worsen in the presence of risk factors such as sepsis, delayed source control, advanced age, and antimicrobial resistance (Koca et al., 2025).

Abdominal physical examination and assessment of vital signs are essential components of the initial evaluation of infection severity. Antimicrobial susceptibility testing also plays a

crucial role in guiding the management of IAI. The emergence of resistant pathogens, such as extended-spectrum beta-lactamase (ESBL)-producing organisms, methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and carbapenem-resistant Enterobacterales (CRE), as well as antifungal resistance, increases the risk of empiric antimicrobial therapy failure and may adversely affect clinical outcomes. Limited access to healthcare services and socioeconomic barriers in areas such as Grobogan Regency may contribute to delays in seeking medical care, resulting in patients presenting at more advanced stages of disease. This issue is consistent with reports from the Indonesian Ministry of Health (2017) regarding the substantial morbidity and mortality associated with IAI in Indonesia due to delayed referral and diagnosis and inappropriate treatment. Therefore, this study aimed to analyze the associations of abdominal physical examination findings, vital signs, and antimicrobial susceptibility results with clinical outcomes in patients undergoing laparotomy for IAI at RSUD Dr. R. Soedjati Soemodardjo Purwodadi Grobogan to support the development of more rational and evidence-based management strategies at the regional healthcare level.

METHOD

Study Design and Subjects

This analytical observational study used a retrospective cohort design and was conducted at RSUD Dr. R. Soedjati Soemodardjo Purwodadi Grobogan. Secondary data were obtained from the medical records of patients who underwent laparotomy for intra-abdominal infection (IAI) between January 2024 and December 2025. Total sampling was used to include all eligible patients during the study period. The inclusion criteria were patients who underwent laparotomy for IAI, had complete medical records containing abdominal physical examination findings, vital signs, clinical outcomes, and antimicrobial susceptibility test results, and completed treatment at the study hospital. Patients who did not complete treatment at the hospital or died before undergoing laparotomy were excluded. Ethical approval was obtained from the Health Research Ethics Committee (KEPK), Faculty of Medicine, Duta Wacana Christian University (No. 1803/C.16/FK/2026).

Procedure

Data were extracted into an anonymized Case Report Form (CRF) using numerical codes. Independent variables included abdominal physical examination findings (muscular defense and abdominal distension), vital signs (MAP, heart rate, respiratory rate, body temperature, and oxygen saturation), and antimicrobial susceptibility test results (ESBL). Dependent variables comprised mortality and length of stay (LOS). The confounding variables assessed were age and preoperative length of stay

Statistical Analysis

Statistical data processing was performed using Statistical Package for the Social Sciences (SPSS) software, with a significance level of $p < 0.05$. Univariate analysis was used to describe sample characteristics. Bivariate analysis was used to assess associations between variables, using the Chi-square or Fisher's exact test for dichotomous categorical variables, and the independent t-test, Mann-Whitney U, or Kruskal-Wallis test for numerical outcomes according to data distribution. Variables with $p < 0.25$ in the bivariate analysis were entered into the multivariate model. Multivariate analysis was performed using Poisson log-linear

generalized-linear-model regression for the dichotomous outcome (mortality) and linear regression for the continuous outcome (LOS).

RESULTS AND DISCUSSION

The study subjects consisted of 60 patients who underwent laparotomy for intra-abdominal infection at RSUD Dr. R. Soedjati Soemodardjo Purwodadi Grobogan between January 2024 and December 2025. The main etiologies were peritonitis due to gastric perforation (35%), perforated appendicitis (16.7%), intra-abdominal abscess (10%), and duodenal perforation (8.3%), with the most common comorbid conditions being intestinal adhesion and sepsis.

Table 1.

Characteristic	Number of patients (n = 60)
Demographic Characteristics	
Age (years), median (min–max)	63.5 (17–89)
Preoperative length of stay (days), median (min–max)	1 (0–9)
Physical Examination and Vital Signs	
Muscular defense	52 (86.7)
Abdominal distension	39 (65)
MAP (mmHg), median (min–max)	89.33 (54–171.67)
Low MAP / High MAP	16 (26.7) / 28 (46.7)
Heart rate (beats/min), mean $\pm$ SD	102.37 $\pm$ 19.97
Tachycardia	33 (55)
Respiratory rate (breaths/min), median (min–max)	23.5 (19–33)
Tachypnea	46 (76.7)
Body temperature (°C)	37 (36–39.4)
Normothermia / Febrile	26 (43.3) / 21 (35)
Oxygen saturation (%), median (min–max)	97 (87–100)
Mild and severe hypoxemia	8 (13.7)
Microbiology	
Most common bacterial isolates, n (%) (mortality %)	
Escherichia coli	18 (30) (22.2)
Klebsiella pneumoniae	11 (18.3) (9.1)
Sterile	11 (18.3) (18.2)
Pseudomonas aeruginosa	6 (10) (66.7)
Candida albicans	5 (8.3) (60)
Klebsiella aerogenes	1 (1.7) (100)
Staphylococcus aureus	1 (1.7) (100)
Sterile	7 (11.7) (0)
ESBL-positive	14 (23.3)
Clinical Outcomes	
Mortality	16 (26.7)
Postoperative complications	18 (30)
Total length of stay (LOS) (days), median (min–max)	6 (0–17)
Surviving patients (days), median (min–max)	6 (3–17)
Deceased patients (days), median (min–max)	5 (0–11)

Data are presented as n (%) unless otherwise stated. MAP: Mean Arterial Pressure; ESBL: Extended-Spectrum Beta-Lactamase; SD: Standard Deviation.

Table 1 shows that the median age of patients was 63.5 years and the median preoperative length of stay was 1 day. Physical examination findings showed that most patients had muscular defense (86.7%) and abdominal distension (65%). A total of 73.3% of patients had abnormal MAP, comprising low MAP in 26.7% and high MAP in 46.7%. Most patients had tachycardia (55%), tachypnea (76.7%), normothermia (43.3%), and hypoxemia (13.7%). Antimicrobial susceptibility testing showed that 23.3% of patients had a positive ESBL result. The mortality rate was 26.7%, and the median LOS was 6 days. Among surviving patients, the median LOS was 6 days, whereas among patients who died, the median LOS was 5 days. The most frequently identified microorganism was *Escherichia coli* (30%), followed by *Klebsiella pneumoniae* and sterile cultures (18.3% each). Mortality was observed across several microorganism groups, with the highest proportions found for *Klebsiella aerogenes* and *Staphylococcus aureus* (100% each), followed by *Pseudomonas aeruginosa* (66.7%) and *Candida albicans* (60%).

Table 2.

Variable	Category	Total, n (%)	Mortality, n (%)	RR (95% CI) / p-value	Mean rank LOS / p-value
Muscular defense	Present	52 (86.7)	15 (28.8)	1.230 (0.898–1.683) p = 0.669	30.82 p = 0.718
	Absent	8 (13.3)	1 (12.5)		28.44
Abdominal distension	Present	39 (65)	16 (41)	1.696 (1.305–2.203) p < 0.001*	31.21 p = 0.669
	Absent	21 (35)	0 (0)		29.19
MAP	Low	16 (26.7)	15 (93.8)	p < 0.001*	20.88 p = 0.013*
	Normal	16 (26.7)	1 (6.5)		38.88
	High	28 (46.7)	0 (0)		31.21
Heart rate	Normal	27 (45)	0 (0)	1.941 (1.394–2.703) p < 0.001*	34.63 p = 0.095
	Tachycardia	33 (55)	16 (48.5)		27.12
Respiratory rate	Normal	14 (23.3)	0 (0)	1.533 (1.242–1.894) p = 0.013*	28.86 p = 0.686
	Tachypnea	46 (76.7)	16 (34.8)		31.00
Body temperature	Hypothermia	10 (16.7)	0 (0)	p < 0.001*	31.40 p = 0.016*
	Normothermia	26 (43.3)	1 (3.8)		37.88
	Subfebrile	3 (5)	0 (0)		21.00
	Febrile	21 (35)	15 (71.4)		22.29
Oxygen saturation	Severe hypoxemia	3 (5)	2 (66.7)	p = 0.044*	23.83 p = 0.580
	Mild hypoxemia	5 (8.3)	3 (60)		36.70
	Normal	52 (86.7)	11 (21.2)		30.29
ESBL	Negative	46 (76.7)	12 (26.1)	1.035 (0.713–1.503) p = 1.000	29.66 p = 0.498
	Positive	14 (23.3)	4 (28.6)		33.25

*statistically significant ($p < 0.05$). MAP: Mean Arterial Pressure; ESBL: Extended-Spectrum Beta-Lactamase; LOS: Length of Stay; RR: Risk Ratio; CI: Confidence Interval.

Table 3.

Variable	Regression coefficient	Adjusted OR	95% CI	p-value
Age – Mortality	0.085	1.088	1.024–1.157	0.007*
Preoperative length of stay – Mortality	-0.005	0.995	0.720–1.373	0.974

*statistically significant ($p < 0.05$). OR: Odds Ratio; CI: Confidence Interval.

Table 4.

Variable	Constant	Regression coefficient	Standardized beta coefficient	95% CI	p-value
Age – LOS	5.266	0.020	0.111	-0.027–0.068	0.397
Preoperative length of stay – LOS	5.122	0.916	0.512	0.512–1.320	< 0.001*

*statistically significant ($p < 0.05$). CI: Confidence Interval.

Table 5.

Variable	Category	Adjusted OR (95% CI)	p-value
Abdominal distension	Present vs. Absent	0.993 (0.608–1.619)	0.976
MAP (ref: Low)	Normal	1.733 (0.685–4.383)	0.245
	High	1.756 (0.709–4.345)	0.223
Heart rate	Tachycardia vs. Normal	0.926 (0.608–1.571)	0.978
Respiratory rate	Tachypnea vs. Normal	0.996 (0.623–1.603)	0.999
Body temperature (ref: Hypothermia)	Normothermia	0.958 (0.540–1.701)	0.884
	Subfebrile	0.964 (0.339–2.742)	0.946
	Febrile	0.955 (0.423–2.155)	0.912
Oxygen saturation (ref: Severe hypoxemia)	Mild hypoxemia	1.049 (0.270–4.070)	0.945
	Normal	1.053 (0.340–3.262)	0.928
Age	—	0.998 (0.985–1.010)	0.721

MAP: Mean Arterial Pressure; OR: Odds Ratio; CI: Confidence Interval.

Table 2 shows a significant association between abdominal distension, MAP, heart rate, respiratory rate, body temperature, and oxygen saturation with mortality ($p < 0.05$). Mortality was more frequently observed among patients with abdominal distension, low MAP, tachycardia, tachypnea, febrile temperature, and hypoxemia. Muscular defense and ESBL results showed no significant association with mortality ($p > 0.05$). In the analysis of LOS, only MAP and body temperature showed significant associations ($p = 0.013$ and $p = 0.016$, respectively), while the remaining variables showed no significant association ($p > 0.05$). Table 3 shows that age was significantly associated with mortality ($p = 0.007$), whereas preoperative length of stay was not significantly associated with mortality ($p = 0.974$). Table 4 shows that preoperative length of stay was significantly associated with LOS ($p < 0.001$), whereas age was not significantly associated with LOS ($p = 0.397$).

Table 6.

Variable	Constant	Regression coefficient	Standardized beta coefficient	95% CI	p-value
MAP	6.329	0.325	0.085	-0.823–1.475	0.572
Heart rate		-0.038	-0.006	-1.726–1.650	0.964
Body temperature		-0.705	-0.250	-1.517–0.108	0.088
Preoperative length of stay		0.911	0.509	0.512–1.311	< 0.001*

*statistically significant ($p < 0.05$). CI: Confidence Interval.

Table 5 shows that the multivariate analysis of the independent variables with mortality found no statistically significant differences ($p > 0.05$). Table 6 shows that MAP, heart rate, and body temperature showed no statistically significant association with LOS ($p > 0.05$), whereas preoperative length of stay showed a significant association with LOS ($p < 0.05$).

Bivariate analysis showed that abdominal distension was significantly associated with patient mortality. The accumulation of gas and fluid resulting from organ perforation and adynamic ileus promotes abdominal wall expansion and increased intra-abdominal pressure (IAP) (Kumar et al., 2021), which carries the risk of progressing to intra-abdominal hypertension (IAH) and compressing the inferior vena cava, thereby reducing venous return and MAP (Blaser et al., 2019), as well as increasing the SOFA score, which correlates directly with mortality (Fuchs et al., 2020; Kumar et al., 2021). Because standard prognostic scoring systems such as SOFA do not incorporate abdominal physical examination (Fuchs et al., 2020), this finding underscores the importance of abdominal physical evaluation as an early prognostic marker. Muscular defense was not significantly associated with mortality, although Suryanto et al. (2025) reported a significant association; the very wide confidence interval (CI) in that study indicates estimation uncertainty resulting from a limited sample size or data heterogeneity (Hespanhol et al., 2019; Suryanto et al., 2025). Muscular defense therefore remains a key diagnostic marker of IAI but cannot be used as a sole predictor of mortality (Suryanto et al., 2025).

Hemodynamic and respiratory evaluation showed that all deaths occurred among patients with low MAP, tachycardia, and tachypnea. A decrease in MAP reflects tissue hypoperfusion in septic shock, which triggers organ dysfunction; a MAP range of 70–82 mmHg is recommended as the optimal therapeutic target for reducing mortality risk (Cao et al., 2022). Sympathetic compensation triggers tachycardia, which increases myocardial oxygen consumption amid a decline in cardiac output, thereby worsening cardiac dysfunction (Na et al., 2023), while diaphragmatic restriction caused by distension and pain stimulates tachypnea (Rivas et al., 2025). Decreased oxygen saturation was also significantly associated with mortality, as hypoxic conditions impair neutrophil oxidative burst in bacterial elimination (Rivas et al., 2025). Body temperature, particularly fever, was significantly associated with mortality. In the elderly population, the febrile response shifts toward becoming a predictor of poor outcomes owing to excessive inflammation, cytokine storm, and metabolic burden (Zhao & Zhang, 2024).

With respect to length of stay (LOS), abdominal physical findings such as distension and muscular defense showed no statistically significant effect. The presence of distension reflects increased IAP and disease complexity (Kumar et al., 2021; Niu et al., 2018), while muscular

defense indicates peritoneal irritation; however, clinical heterogeneity between cases reduced the attained statistical power (Cuijpers et al., 2021). Among vital signs, MAP and body temperature were significantly associated with LOS, whereas heart rate, respiratory rate, and oxygen saturation were not significant. The low-MAP, tachycardic, and severely hypoxemic groups tended to show a shorter LOS owing to early mortality within these groups (Pantis et al., 2026), whereas surviving tachypneic subjects had a longer LOS. An imbalanced distribution of subjects also contributed to reduced statistical power (Cuijpers et al., 2021). Body temperature displayed a "U"-shaped pattern, in which subfebrile temperature appeared protective and accelerated recovery, whereas fever precipitated early mortality and shortened LOS (Chen et al., 2024). These findings reinforce LOS as a marker of clinical complexity and patient survival (Niu et al., 2018).

ESBL testing showed no significant difference with respect to mortality or LOS. This finding differs from studies of multidrug-resistant (MDR) and extensively drug-resistant (XDR) organisms, which increase mortality and LOS owing to inadequate empirical therapy and the toxicity of advanced-line agents (Koca et al., 2025). The absence of significance for ESBL may be explained by the fact that ESBL-related resistance is confined to the beta-lactam class, which can be addressed with carbapenems or beta-lactamase-inhibitor combinations (Angelo et al., 2016); the availability and use of these antibiotic classes are very high in Indonesia (Limato et al., 2021).

Evaluation of the confounding variables showed that preoperative length of stay significantly affected total LOS but not mortality. Delayed surgery carries the risk of expanding contamination and septic-toxin spread (Murray et al., 2021); however, surgical delay is generally intentional, aimed at resuscitation and hemodynamic stabilization, thereby increasing total LOS without directly increasing mortality (Loftus et al., 2018). Age was significantly associated with mortality owing to decreased physiological reserve, frailty, immunosenescence, and the high prevalence of comorbidities in elderly patients (Arvaniti et al., 2022).

In the multivariate analysis of mortality, no variable was found to be independently significant, likely reflecting a mutually canceling effect between predictive and protective factors (Rajabaleyan et al., 2025), with MAP and age remaining the strongest predictors of survival. Differences in statistical categorization may have prevented the non-linear effect of MAP (> 82 mmHg) from being detected in this model (Cao et al., 2022). Multivariate analysis of LOS showed that preoperative length of stay was the most dominant independent predictor (Loftus et al., 2018). The loss of significance of MAP and body temperature in the multivariate model indicates the presence of confounding effects and collinearity when physiological variables are analyzed simultaneously (Johnston et al., 2018).

This study has several limitations, including the use of a retrospective cohort design based on secondary data, which depends on the completeness of medical-record documentation. This study did not account for confounding variables such as antibiotic type and specific diagnosis, did not apply a clinical severity scoring system such as the SOFA score, and did not analyze MDR patterns in greater depth. The limited sample size and data heterogeneity restrict the generalizability of the results, reduce statistical power, and contribute to the absence of independently significant variables in the multivariate analysis.

CONCLUSION

Abdominal physical examination findings and vital signs were associated with clinical outcomes following laparotomy for intra-abdominal infection. Abdominal distension was significantly associated with mortality, whereas mean arterial pressure (MAP) and body temperature were significantly associated with both mortality and length of stay (LOS). Heart rate, respiratory rate, and oxygen saturation were also significantly associated with mortality. No significant association was found between extended-spectrum beta-lactamase (ESBL) status and either clinical outcome. In the multivariable analysis, no independent predictor of mortality was identified, whereas preoperative length of stay was independently associated with prolonged LOS.

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CONFLICT OF INTEREST

The authors declare that there are no personal, commercial, or financial conflicts of interest that could have influenced the conduct or outcomes of this study.

AUTHOR CONTRIBUTION

Afif Iman Hidayat contributed to the study design, data collection and processing, system development, analysis of the results, and preparation of the manuscript.

GENERATIVE ARTIFICIAL INTELLIGENCE USAGE STATEMENT

During the preparation of this article, the author used generative artificial intelligence (AI) as a supporting tool for language refinement, structural organization, and grammatical correction. The use of AI was limited and remained under the author's supervision. All data, analyses, interpretations, and scientific content presented in this article were reviewed and verified by the author. The author assumes full responsibility for the accuracy, originality, and final content of the manuscript. (Alshamari, 2026)

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