



Original Article

Divert or Anastomose? A Decade of Independent Predictors of Stoma Creation in Emergency Colorectal Surgery at a Resource-Limited Provincial Hospital

A 10-Year Retrospective Cohort Study, Phatthalung Hospital, Thailand (2015–2025)

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ABSTRACT

Objective: The intraoperative decision to restore bowel continuity or create a stoma during emergency colorectal resection is complex, and the factors that drive this decision remain poorly characterised, particularly in resource-limited settings. We aimed to identify independent predictors of stoma creation among adults undergoing emergency colorectal resection at a Thai provincial referral hospital.

Materials and Methods: We conducted a retrospective cohort study of consecutive adult patients undergoing emergency colorectal resection at Phatthalung Hospital, a provincial referral hospital in southern Thailand, between January 2015 and December 2025. Candidate predictors spanning eight pre-specified domains—demographic characteristics, body mass index, physiological reserve, physiological compromise, immunonutritional status, disease characteristics, surgeon factors, and operative context—were evaluated using univariable and Firth penalised multivariable logistic regression. A full model incorporating all covariates and a physiologic model excluding disease location (to isolate non-anatomical predictors) were compared.

Results: Of 371 patients, 190 (51.2%) underwent stoma creation. Disease location was the dominant predictor: only 1 of 93 patients (1.1%) with right colonic disease received a stoma, compared with 43.9% with left colonic and 75.5% with sigmoid or rectal disease. After adjustment, ASA class III (aOR 2.53), high-risk MPI (aOR 5.00), and surgeon experience 5–10 vs <5 years (aOR 2.83) were associated with higher odds of stoma creation, while morbid obesity was associated with lower odds (aOR 0.19), an estimate based on only 14 patients. The full model demonstrated excellent discrimination (area under the curve [AUC] 0.889); the physiologic model excluding disease location retained acceptable discrimination (AUC 0.697). Thirty-day mortality was similar between the stoma and anastomosis groups (8.4% vs 9.4%), but

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only 15 of 190 stomas (7.9%) were subsequently reversed, predominantly because of cancer progression or medical unfitness for further surgery.

Conclusion: In this resource-limited provincial setting, half of all patients undergoing emergency colorectal resection received a stoma, driven primarily by disease location, peritonitis severity, and physiological reserve rather than by surgeon or timing factors alone. Given the very low reversal rate, the decision to divert should be regarded as a de facto decision for a permanent stoma in most patients, reinforcing the need for objective decision-support tools and realistic preoperative counselling in resource-limited surgical settings.

Keywords: emergency colorectal surgery, stoma creation, primary anastomosis, Hartmann's procedure, surgical decision-making, Mannheim Peritonitis Index

Introduction

Emergency colorectal surgery spans life-threatening conditions — obstruction, perforation, ischaemia, severe infection and trauma — in patients who, unlike elective candidates, often present haemodynamically unstable and with unprepared bowel, and it carries substantially higher morbidity, mortality and resource use than elective surgery.^{1,2}

A central intraoperative decision is whether to restore continuity by primary anastomosis or to divert with a stoma. Anastomosis avoids the burden of a stoma but risks leakage, with failure-to-rescue rates up to 7.8% when diagnosis is delayed.³ Diversion may limit the consequences of leak but risks permanence: reported permanent-stoma rates range from 20% to 70%, with contemporary reversal below one-third,^{4,5} a proportion likely lower still where cancer burden,

comorbidity and health-system capacity further constrain elective reversal.

Landmark randomised trials — Oberkofler, Binda, DIVERTI and the diverting-ileostomy (DIVA) arm of LADIES — show that primary anastomosis can be performed safely, with higher stoma-free survival than Hartmann's procedure, in carefully selected, haemodynamically stable patients,^{6,7,8,9,10} and large observational studies corroborate this where surgical expertise and perioperative support are adequate,¹¹ shifting practice away from Hartmann's procedure as the default operation for emergency left-sided colorectal disease.

Most evidence, however, compares operative strategies and outcomes rather than the factors that drive the decision to divert. Surgeons must integrate physiological status, disease severity and operative findings under time pressure, and although guidelines endorse individualised



decision-making, empirical evidence on how these factors interact remains limited.¹ This gap is especially consequential in provincial hospitals with limited intensive care capacity, variable laboratory access, heterogeneous surgeon experience and no on-site colorectal subspecialists — conditions under which the diversion threshold may differ from tertiary centres. International audits confirm wide variation in emergency colorectal outcomes between high- and low/middle-income settings,^{2,11} yet predictor studies originate largely from high-resource centres and rarely model physiological, anatomical and surgeon-related factors simultaneously.

We therefore aimed to identify independent predictors of stoma creation among adults undergoing emergency colorectal surgery at a Thai provincial referral hospital over ten years. We evaluated demographic, physiological, disease, operative and surgeon-related factors using Firth penalised logistic regression to characterise determinants of the decision rather than compare operative strategies or outcomes. Doing so could improve decision-making consistency, support counselling and inform decision-support tools in similar resource-limited settings.

Materials And Methods

Study Design and Setting

This retrospective cohort study included consecutive adults undergoing emergency

colorectal resection at Phatthalung Hospital, a 567-bed provincial referral hospital serving ~500,000 people in southern Thailand, providing 24-hour emergency surgery without dedicated acute care surgery infrastructure, on-site colorectal subspecialists, or continuous intensivist coverage; surgery is performed by general surgeons of varying post-certification experience. Fourteen surgeons performed the study's 371 operations, with substantial caseload imbalance (range 1–82 cases; the two highest-volume surgeons accounted for 38.8% of operations). Several low-volume surgeons were board-certified colleagues from neighbouring hospitals providing on-call cover, with training comparable to core staff; surgeon experience category, not individual identity, was therefore the analytic exposure of interest throughout this study. The study followed the STROBE statement.¹²

Participants

All adults (≥ 18 years) undergoing emergency colorectal resection between 1 January 2015 and 31 December 2025 were identified from operative logbooks and electronic records. Emergency surgery was defined as unplanned resection for obstruction, perforation, ischaemia/volvulus, severe infection, or trauma. Exclusions were elective/semi-elective surgery, emergency surgery without resection (e.g. diverting stoma alone or adhesiolysis), appendectomy or isolated small-bowel resection, revision/closure of a pre-existing

stoma, and insufficient documentation; all eligible patients were included without sampling.

Primary Outcome

The primary outcome was intraoperative stoma creation — construction of any stoma (end colostomy/Hartmann's procedure, loop colostomy, end or loop ileostomy) versus primary anastomosis without diversion, classified from operative notes.

Candidate Predictor Variables

Candidate predictors spanned eight pre-specified domains (Table 1). Shock Index (heart rate ÷ systolic blood pressure) was measured on ED arrival, with ≥ 0.9 defining haemodynamic instability.¹³ Serum bicarbonate < 22 mEq/L served as a metabolic-acidosis surrogate (lactate 97% missing).¹⁴ Total lymphocyte count $< 1,500$ cells/

mm³ served as an immunonutritional surrogate (albumin 39.1% missing).¹⁵ The Mannheim Peritonitis Index (MPI) was stratified into low (< 21), intermediate (21–29), and high (≥ 30) risk.^{16,17} BMI used Thai/Asia-Pacific cut-points, with normal weight (18.5–22.9 kg/m²) as reference.

All data were abstracted from operative notes, anaesthetic records, and electronic records by a single reviewer (T.P.) using a structured data-entry form; MPI was calculated item-by-item using the standard eight-component formula, rather than free-text estimation. To assess abstraction reliability, 30 records (8.1% of the cohort) — consistent with typical 5–10% QA sampling fractions in retrospective chart reviews — were re-abstracted independently; all values, including MPI component scores and risk category, were concordant with the original entries.

Table 1 Pre-specified candidate predictor variable definitions

Variable	Measurement	Definition/threshold	Reference/rationale
1. Demographic characteristics			
Age	Years at surgery	Continuous; per 10-y increase in multivariable model	
Sex	Operative record	Binary (male/female); male as reference	
2. Body mass index			
BMI	Weight/height ²	$< 18.5/18.5\text{--}22.9$ (ref)/ $23.0\text{--}24.9/25.0\text{--}29.9$ / ≥ 30.0 kg/m ²	Thai/Asia-Pacific cut-points (WHO 2004)

Table 1 (cont.) Pre-specified candidate predictor variable definitions

Variable	Measurement	Definition/threshold	Reference/rationale
3. Physiological reserve			
ASA physical status	Pre-anaesthetic assessment	Ordinal I-IV; I-II combined as reference	ASA classification system
4. Physiological compromise			
Shock Index	HR ÷ SBP (ED arrival)	Binary: ≥ 0.9 vs < 0.9	Allgöwer & Burri 1967. ¹³
Serum bicarbonate	Pre-op blood gas	Binary: < 22 mEq/L	Lactate missing 97%; bicarbonate as surrogate. ¹⁴
Inotropic/vasopressor support	Pre-op medication record missing-data assumption	Binary: yes/no	Conservative
5. Immunonutritional status			
Total lymphocyte count	FBC on ED arrival	Binary: $< 1,500$ cells/mm ³	Albumin missing 39.1%; TLC as surrogate.
6. Disease characteristics			
MPI risk category	Intraoperative assessment (8 items)	Low < 21 (ref)/Intermediate 21–29 / High ≥ 30	Linder & Wacha 1987; ¹⁶ Billing 1994. ¹⁷
Disease location	Operative note	Right colon (ref)/Left colon/Sigmoid or rectum	Anatomical classification
Indication for surgery	Operative note	Obstruction (ref)/Perforation/Other	
Colorectal malignancy	Operative note/pathology	Binary: known or suspected at time of surgery	Derived from clinical diagnosis, not MPI item
7. Surgeon factors			
Surgeon experience	Board certification date	Junior < 5 yr (ref)/Middle 5–10 yr/Senior > 10 yr post-certification	Thai Board of Surgery
8. Operative context and timing			
Time of surgery	Operative start time	Morning 08:00–16:00 (ref)/Afternoon 16:00–00:00/Night 00:00–08:00	
ED-to-operation time	Time from ED arrival to incision	Continuous; per 1-hour increase	Timeliness of surgical care



Secondary Outcomes

Secondary outcomes, assessed descriptively, were 30-day mortality, total in-hospital mortality (30-day plus later in-hospital death), anastomotic leakage (after primary anastomosis only), failure to extubate immediately, ICU admission, any postoperative complication, hospital length of stay, and stoma closure at last follow-up, including reasons for non-closure. Anastomotic leak was assessed only among patients in whom an anastomosis was constructed. One record coded as leak in a patient who had undergone Hartmann's procedure was corrected during data verification, the medical record having confirmed that no leak occurred.

Statistical Analysis

Continuous variables are summarised as mean $\pm$ SD or median (IQR); categorical variables as frequency and percentage, with standardised mean differences (SMD) for between-group comparisons. Missing data are reported per variable; complete-case analysis was used for all multivariable models without imputation.

Univariable associations were assessed by binary logistic regression, reporting crude odds ratios (95% CI) and P values (likelihood-ratio test for categorical variables); significance was set at $P < 0.05$. These analyses informed variable characterisation and the pre-specified multivariable model rather than serving as independent

hypothesis tests; no correction for multiple comparisons was applied, as the multivariable model is the primary, confirmatory analysis.

Multivariable analysis used Firth penalised logistic regression,¹⁸ to address small-sample bias and quasi-complete separation from disease location (only 1 of 93 right-sided cases underwent stoma creation); all candidate variables were entered simultaneously per the pre-specified plan. Events per parameter (EPP), calculated as outcome events $\div$ model parameters (excluding intercept), was ≥ 5 , the accepted threshold for Firth regression.¹⁹ Two complementary models were fitted: a full model with all eight domains, and a physiologic model excluding disease location to evaluate non-anatomical predictors after removing the dominant anatomical determinant. Adjusted odds ratios with 95% penalised Wald CIs are reported.²⁰

Model performance was evaluated using AUC, Brier score, McFadden's R^2 , AIC, and BIC; multicollinearity was assessed by pairwise Pearson correlation and generalised VIF. Analyses used R (version 4.6.0) with the logistf and pROC packages.

Ethics and Data Governance

This study was approved by Phatthalung Hospital's Institutional Review Board (IRB No. 16/2569; approved 30 April 2026; valid until 29 April 2027). Informed consent was waived given the retrospective design and use of anonymised

routinely collected data. Patient identifiers were removed and data stored on a password-protected institutional server per the Personal Data Protection Act B.E. 2562 (Thailand).

Results

Patient Selection and Cohort Characteristics

Of 1,203 consecutive colorectal surgical records reviewed (January 2015–December 2025), 832 were excluded (789 elective, 43

non-colorectal, remainder diversion-only or insufficient documentation), leaving 371 patients undergoing emergency colorectal resection (Figure 1). Stoma creation occurred in 190 (51.2%) and primary anastomosis in 181 (48.8%) — substantially exceeding our pre-study estimate of ~19%, reflecting this setting’s physiologically challenging case-mix. Annual case volume and stoma-creation rates across the study period are shown in Figure 2.

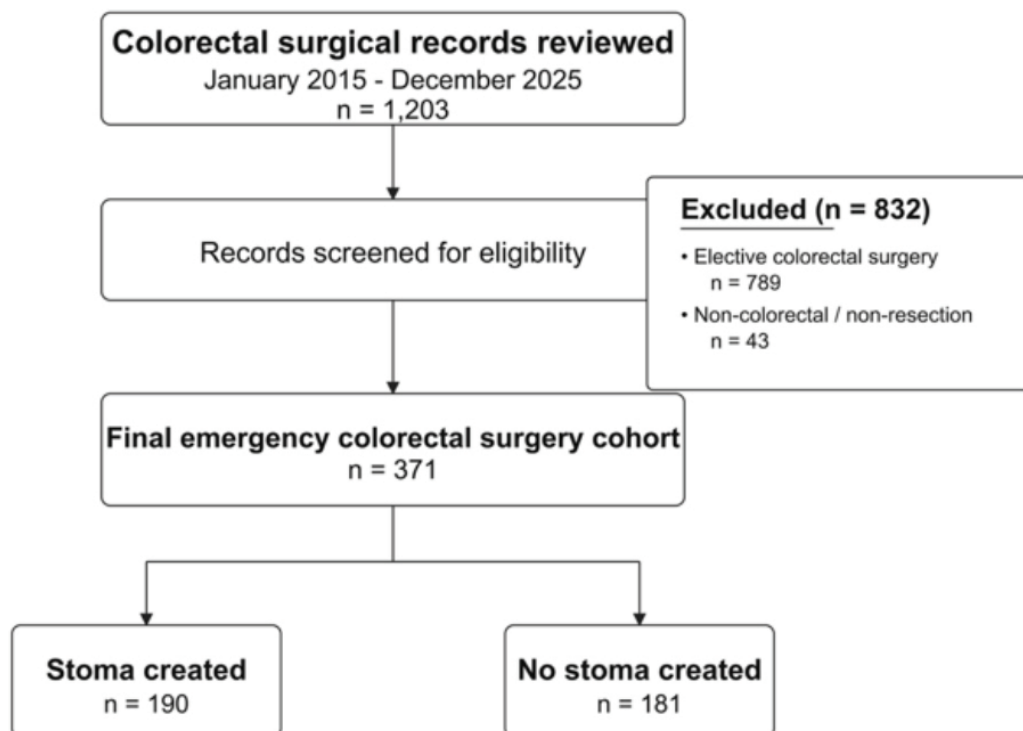
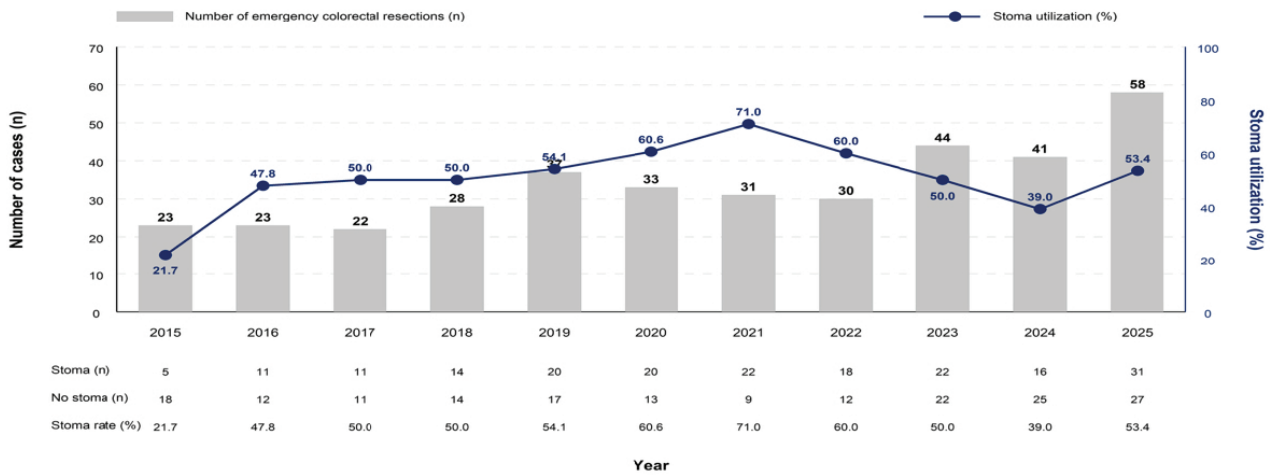


Figure 1 Flow diagram of patient selection. Of 1,203 colorectal surgical records reviewed, 371 patients formed the final cohort.

Temporal trends in emergency colorectal surgery volume and stoma utilization (2015-2025).



Gray bars indicate the annual number of emergency colorectal resections. The blue line represents the proportion of patients who underwent stoma creation. Although operative volume increased over time, stoma utilization varied between years, reflecting changes in case-mix, disease severity, and clinical context.

Figure 2 Temporal trends in emergency colorectal surgery volume and stoma utilization, 2015–2025. Annual emergency colorectal resection volume and stoma-creation rates. Gray bars show case volume; the blue line shows the proportion undergoing stoma creation, which fluctuated year to year despite rising volume, reflecting case-mix and disease severity rather than volume alone.

Baseline Characteristics

Table 2 Baseline Characteristics According to Stoma Creation

Characteristic	Overall (N=371)	No stoma (n=181)	Stoma (n=190)	SMD
Demographic characteristics				
Age, yr	67.0 (54.0-76.0)	63.0 (51.0-74.0)	70.0 (57.2-77.8)	0.35
Male sex	240 (64.7)	112 (61.9)	128 (67.4)	0.12
Body mass index category, Thai criteria				
Underweight (< 18.5)	91 (24.8)	43 (24.0)	48 (25.5)	0.26
Normal weight (18.5-22.9)	170 (46.3)	81 (45.3)	89 (47.3)	
Overweight / at risk (23.0-24.9)	40 (10.9)	17 (9.5)	23 (12.2)	
Obese (25.0-29.9)	52 (14.2)	27 (15.1)	25 (13.3)	
Morbid obesity (≥ 30.0)	14 (3.8)	11 (6.1)	3 (1.6)	



Table 2 (cont.) Baseline Characteristics According to Stoma Creation

Characteristic	Overall (N=371)	No stoma (n=181)	Stoma (n=190)	SMD
Comorbidities				
Diabetes mellitus	35 (9.4)	15 (8.3)	20 (10.5)	0.08
Hypertension	64 (17.3)	26 (14.4)	38 (20.0)	0.15
Chronic kidney disease	6 (1.6)	4 (2.2)	2 (1.1)	0.09
Chronic obstructive pulmonary disease	4 (1.1)	1 (0.6)	3 (1.6)	0.10
Physiological reserve				
ASA physical status				0.68
I-II	153 (41.2)	98 (54.1)	55 (28.9)	
III	202 (54.4)	79 (43.6)	123 (64.7)	
IV	16 (4.3)	4 (2.2)	12 (6.3)	
Physiological compromise				
Preoperative inotropic/vasopressor support	42 (11.3)	15 (8.3)	27 (14.2)	0.19
Elevated shock index (≥ 0.9)	53 (14.3)	21 (11.7)	32 (16.8)	0.15
Low serum bicarbonate (< 22 mEq/L)	92 (25.1)	42 (23.7)	50 (26.5)	0.06
Immunonutritional status				
Low total lymphocyte count (< 1500 cells/mm ³)	238 (64.3)	105 (58.3)	133 (70.0)	0.25
Disease characteristics				
Diagnosis				0.16
Obstruction	263 (70.9)	123 (68.0)	140 (73.7)	
Perforation	87 (23.5)	46 (25.4)	41 (21.6)	
Other	21 (5.7)	12 (6.6)	9 (4.7)	
Colorectal malignancy	290 (78.2)	134 (74.0)	156 (82.1)	0.20
Mannheim Peritonitis Index risk category				
Low risk (< 21)	251 (67.7)	129 (71.3)	122 (64.2)	0.16
Intermediate risk (21-29)	69 (18.6)	35 (19.3)	34 (17.9)	
High risk (≥ 30)	51 (13.7)	17 (9.4)	34 (17.9)	
Peritonitis type				
No peritonitis	258 (70.5)	124 (68.9)	134 (72.0)	0.28
Purulent peritonitis	57 (15.6)	37 (20.6)	20 (10.8)	
Fecal peritonitis	51 (13.9)	19 (10.6)	32 (17.2)	

Table 2 (cont.) Baseline Characteristics According to Stoma Creation

Characteristic	Overall (N=371)	No stoma (n=181)	Stoma (n=190)	SMD
Disease location				1.41
Right colon	93 (25.1)	92 (50.8)	1 (0.5)	
Left colon	66 (17.8)	37 (20.4)	29 (15.3)	
Sigmoid/rectum	212 (57.1)	52 (28.7)	160 (84.2)	
Operative context				
Time of surgery				0.16
Morning shift	87 (23.6)	38 (21.3)	49 (25.8)	
Afternoon shift	193 (52.4)	99 (55.6)	94 (49.5)	
Night shift	88 (23.9)	41 (23.0)	47 (24.7)	
Timing of presentation				
Emergency department-to-operation time, h	7.0 (4.0-14.0)	7.0 (5.0-13.0)	6.0 (4.0-14.0)	0.10
Symptom onset-to-operation				0.20
< 1 day	14 (3.8)	8 (4.4)	6 (3.2)	
1-2 days	227 (61.2)	119 (65.7)	108 (56.8)	
> 2 days	130 (35.0)	54 (29.8)	76 (40.0)	

Values are median (IQR) or No. (%), as appropriate. BMI was categorized using Thai/Asia-Pacific cut points: underweight < 18.5, normal 18.5-22.9, overweight/at risk 23.0-24.9, obese 25.0-29.9, and morbid obesity ≥ 30.0 kg/m². BMI data were missing in 4 patients; BMI category percentages were calculated among patients with available BMI data (overall n=367, no stoma n = 179, stoma n=188). Baseline characteristics are presented descriptively; between-group differences use standardized mean differences (SMDs). SMD ~0.10/0.20/0.50 indicate small/moderate/large differences. Comorbidities were identified from the recorded free-text comorbidity field using prespecified keywords. Total lymphocyte count served as an immunonutritional marker, though it may also reflect acute inflammatory stress.²¹ Other diagnoses included intussusception, ischemia, volvulus, bleeding, trauma/injury, and other uncommon presentations. MPI remains continuous in the primary multivariable model. Time of surgery was coded as 1=morning shift, 2=afternoon shift, and 3=night shift. Lactate was excluded because of high missingness and unresolved unit consistency.

Baseline characteristics are presented in [Table 2](#). The cohort had a median age of 67.0 years (IQR 54.0–76.0); patients undergoing stoma creation were older (median 70.0 vs 63.0 years) with

substantially greater ASA III/IV burden (71.1% vs 45.9%). Male sex (64.7% overall) and comorbidity prevalence (30.5%) were similar between groups.



Disease Presentation and Operative Findings

Disease presentation and operative findings appear in Table 2. Obstruction was the commonest indication (70.9%), followed by perforation (23.5%). Colorectal malignancy was present in 78.2% of cases, numerically more common in the stoma group (82.1% vs 74.0%; $P = 0.060$).

Disease location exerted the strongest influence on operative strategy: only 1 of 93 patients (1.1%) with right colonic disease received a stoma, compared with 29 of 66 (43.9%) with left colonic and 160 of 212 (75.5%) with sigmoid or rectal disease — together accounting for 99.5% of all stoma procedures.

Peritoneal contamination was absent/localised in 70.9%, purulent in 15.4%, and faecal in 13.7%. Median MPI was 15.0 (IQR 9.0–24.0); stoma rate rose progressively across MPI risk categories (48.6%, 49.3%, 66.7% for low, intermediate, high risk, respectively). Operative time was shorter in the stoma group (median 67.5 vs 105.0 min), consistent with an expedient approach in

physiologically compromised patients.

Surgeon experience (< 5 years 49.5%, 5–10 years 24.1%, > 10 years 26.5%) showed no significant univariable association with stoma creation ($P = 0.232$).

Univariable and Multivariable Analysis

Univariable results are presented in Table 3. Disease location showed by far the strongest crude association (left colonic and sigmoid/rectal both markedly elevated versus right colon; both $P < 0.001$), reflecting the near-separation necessitating Firth regression. Older age, higher ASA class, and comorbidity presence were each associated with stoma creation (all $P < 0.05$), as was lower total lymphocyte count ($P = 0.010$); Shock Index showed a borderline association ($P = 0.051$). Surgical indication was not significantly associated ($P = 0.776$). Operative time was significantly shorter ($P < 0.001$) and intraoperative hypotension more frequent (22.6% vs 13.9%; $P = 0.042$) in the stoma group.

Table 3 Univariable Logistic Regression for Factors Associated With Stoma Creation

Variable	No. analyzed	Crude OR (95% CI)	P value	Global P value
Demographic characteristics				
Age, per 10-y increase	371	1.27 (1.10-1.46)	< 0.001	< 0.001
Male sex	371	1.27 (0.83-1.95)	0.269	0.269
Body mass index category, Thai criteria	367			0.180
Normal weight (18.5-22.9)	367	Reference		
Underweight (< 18.5)	367	1.02 (0.61-1.69)	0.952	
Overweight/at risk (23.0-24.9)	367	1.23 (0.61-2.47)	0.558	
Obese (25.0-29.9)	367	0.84 (0.45-1.57)	0.590	
Morbid obesity (≥ 30.0)	367	0.25 (0.07-0.92)	0.037	
Comorbidities				
Diabetes mellitus	371	1.30 (0.64-2.63)	0.462	0.462
Hypertension	371	1.49 (0.86-2.57)	0.153	0.153
Chronic kidney disease	371	0.47 (0.09-2.60)	0.388	0.388
Chronic obstructive pulmonary disease	371	2.89 (0.30-28.02)	0.360	0.360
Physiological reserve				
ASA physical status	371			< 0.001
I-II	371	Reference		
III	371	2.77 (1.80-4.28)	< 0.001	
IV	371	5.35 (1.64-17.38)	0.005	
Physiological compromise				
Preoperative inotropic/vasopressor support	371	1.83 (0.94-3.57)	0.075	0.075
Elevated shock index (≥ 0.9)	370	1.53 (0.85-2.77)	0.158	0.158
Low serum bicarbonate (< 22 mEq/L)	366	1.16 (0.72-1.86)	0.548	0.548
Immunonutritional status				
Low total lymphocyte count (< 1,500 cells/mm ³)	370	1.67 (1.09-2.56)	0.020	0.020
Disease characteristics				
Diagnosis	371			0.450
Obstruction	371	Reference		
Perforation	371	0.78 (0.48-1.27)	0.324	
Other	371	0.66 (0.27-1.62)	0.362	
Colorectal malignancy	371	1.61 (0.98-2.65)	0.061	0.061

Table 3 (cont.) Univariable Logistic Regression for Factors Associated With Stoma Creation

Variable	No. analyzed	Crude OR (95% CI)	P value	Global P value
Mannheim Peritonitis Index risk category	371			0.056
Low risk (< 21)	371	Reference		
Intermediate risk (21-29)	371	1.03 (0.60-1.75)	0.921	
High risk (≥ 30)	371	2.11 (1.12-3.98)	0.020	
Peritonitis type	366			0.012
No peritonitis	366	Reference		
Purulent peritonitis	366	0.50 (0.28-0.91)	0.023	
Fecal peritonitis	366	1.56 (0.84-2.89)	0.159	
Disease location	371			< 0.001
Right colon	371	Reference		
Left colon	371	72.11 (9.47-548.86)	< 0.001	
Sigmoid/rectum	371	283.08 (38.49-2081.86)	< 0.001	
Surgeon factors				
Surgeon experience	370			0.232
< 5 year	370	Reference		
5-10 years	370	1.24 (0.75-2.07)	0.403	
> 10 years	370	0.75 (0.46-1.24)	0.263	
Operative context				
Time of surgery	368			0.463
Morning shift	368	Reference		
Afternoon shift	368	0.74 (0.44-1.23)	0.239	
Night shift	368	0.89 (0.49-1.61)	0.699	
Variable	No. analyzed	Crude OR (95% CI)	P value	Global P value
Timing of presentation				
Emergency department-to-operation time, per h	371	0.99 (0.96-1.01)	0.338	0.338
Symptom onset-to-operation	371			0.114
< 1 day	371	Reference		
1-2 days	371	1.21 (0.41-3.60)	0.732	
> 2 days	371	1.88 (0.62-5.72)	0.268	

The outcome was stoma creation (1 = stoma; 0 = no stoma). Separate univariable logistic regression models were fitted for each predictor.

Age is per 10-year increase; ED-to-operation time per 1-hour increase. Shock Index, bicarbonate, TLC, and MPI used the categories in Table 1. Global P values (categorical, > 2 levels) used likelihood-ratio tests. Morning shift was the reference category. Disease location produced sparse cells and near-separation; crude estimates should therefore be interpreted cautiously.

The full multivariable model — incorporating demographic, physiological, immunonutritional, disease, operative, and surgeon-related covariates — was fitted using Firth penalised logistic regression on 358 patients with complete data (Table 4), showing excellent discrimination (AUC 0.889; Figure 3).

Disease location remained the dominant predictor (left colon aOR 69.82, 95% CI 12.55–388.44; sigmoid/rectal aOR 266.48, 95% CI 49.49–1434.81; both $P < 0.001$); the very wide CIs reflect near-complete separation and should be interpreted cautiously.

After adjustment, ASA class III was

independently associated with stoma creation (aOR 2.53, $P = 0.007$), as was high-risk MPI (aOR 5.00, $P = 0.023$). Morbid obesity (BMI ≥ 30.0 kg/m²) was associated with significantly lower odds (aOR 0.19, $P = 0.046$). This estimate rested on 3 stoma events among 14 patients, with a confidence interval reaching unity (0.04–0.97), and was not significant in the physiologic model (aOR 0.28, 95% CI 0.07–1.15; $P = 0.077$). Surgeon experience 5–10 vs < 5 years was associated with higher odds (aOR 2.83, $P = 0.029$), while afternoon-shift operations showed lower odds than morning shifts (aOR 0.34, $P = 0.011$).

Table 4 Factors Associated With Stoma Creation: Multivariable Firth Penalised Logistic Regression

Variable	Full model ^a		Physiologic model ^b	
	aOR (95% CI)	P value	aOR (95% CI)	P value
Demographic characteristics				
Age, per 10-y increase	0.94 (0.75–1.19)	0.611	1.02 (0.86–1.21)	0.825
Male sex	1.82 (0.97–3.43)	0.063	1.31 (0.79–2.15)	0.291
Body mass index category^c — aOR		0.023		0.021
Reference	1.00 (reference)	—	1.00 (reference)	—
Underweight (< 18.5)	0.98 (0.48–2.01)	0.960	0.97 (0.55–1.71)	0.909
Overweight / at risk (23.0–24.9)	0.97 (0.37–2.52)	0.949	1.01 (0.48–2.13)	0.985
Obese (25.0–29.9)	1.44 (0.57–3.66)	0.442	0.93 (0.47–1.86)	0.839
Morbid obesity (≥ 30.0)	0.19 (0.04–0.97)	0.046	0.28 (0.07–1.15)	0.077
Physiologic reserve				
ASA physical status — aOR		0.006		< 0.001
Reference	1.00 (reference)	—	1.00 (reference)	—
Class III	2.53 (1.28–5.00)	0.007	2.32 (1.36–3.96)	0.002
Class IV	3.10 (0.48–19.97)	0.234	3.30 (0.81–13.36)	0.095

Table 4 (cont.) Factors Associated With Stoma Creation: Multivariable Firth Penalised Logistic Regression

Variable	Full model ^a		Physiologic model ^b	
	aOR (95% CI)	P value	aOR (95% CI)	P value
Physiologic compromise				
Elevated shock index (≥ 0.9)	0.57 (0.18–1.76)	0.326	0.93 (0.39–2.22)	0.866
Low serum bicarbonate (< 22 mEq/L)	0.53 (0.26–1.10)	0.090	0.69 (0.38–1.23)	0.203
Preoperative inotropic/ vasopressor support ^d	2.02 (0.52–7.92)	0.313	1.07 (0.38–3.05)	0.893
Immunonutritional status				
Low total lymphocyte count ($< 1,500$ cells/mm ³)	1.38 (0.74–2.58)	0.305	1.57 (0.96–2.57)	0.075
Disease characteristics				
Mannheim Peritonitis Index risk category — aOR		0.014		0.014
Reference	1.00 (reference)	—	1.00 (reference)	—
Intermediate risk (21–29)	1.42 (0.57–3.54)	0.448	1.28 (0.63–2.64)	0.495
High risk (≥ 30)	5.00 (1.25–19.94)	0.023	3.01 (1.05–8.59)	0.040
Disease location ^c — aOR		< 0.001	Excluded from model	
Right colon	1.00 (reference)	—	Excluded	Excluded
Left colon	69.82 (12.55–388.44)	< 0.001	Excluded	Excluded
Sigmoid/rectum	266.48 (49.49–1434.81)	< 0.001	Excluded	Excluded
Diagnosis — aOR		0.051		0.009
Reference	1.00 (reference)	—	1.00 (reference)	—
Perforation	0.42 (0.15–1.19)	0.103	0.39 (0.18–0.87)	0.021
Other	0.33 (0.08–1.31)	0.115	0.48 (0.16–1.47)	0.201
Colorectal malignancy	0.78 (0.32–1.88)	0.581	1.31 (0.70–2.46)	0.401
Surgeon factors				
Surgeon experience (< 5 years reference) — aOR		0.010		0.062
< 5 years	1.00 (reference)	—	1.00 (reference)	—
5–10 years	2.83 (1.11–7.21)	0.029	1.27 (0.66–2.46)	0.473
> 10 years	1.23 (0.65–2.33)	0.527	1.11 (0.66–1.84)	0.699

Table 4 (cont.) Factors Associated With Stoma Creation: Multivariable Firth Penalised Logistic Regression

Variable	Full model ^a		Physiologic model ^b	
	aOR (95% CI)	P value	aOR (95% CI)	P value
Operative context				
Time of surgery — aOR		0.003		0.017
Reference	1.00 (reference)	—	1.00 (reference)	—
Afternoon shift	0.34 (0.15–0.79)	0.011	0.60 (0.33–1.09)	0.091
Night shift	0.60 (0.24–1.52)	0.280	0.79 (0.39–1.60)	0.515
Timing of presentation				
Emergency department-to-operation time, per h	1.00 (0.95–1.04)	0.836	0.98 (0.95–1.01)	0.234
Model diagnostics				
Complete cases	358		358	
Events (stoma)	187		187	
Parameters, excluding intercept	24		22	
Events per parameter	7.1		7.8	
AIC	332.2		491.1	
BIC	429.2		580.4	
AUC (c-statistic)	0.889		0.697	
Brier score	0.128		0.217	
McFadden R ²	0.431		0.102	
Maximum VIF	2.5		2.5	

^a Full model: included all covariates, including disease location; Firth penalised regression was used because disease location produced sparse cells and near-complete separation. ^b Physiologic model: disease location was excluded to evaluate non-anatomical predictors after removing the dominant anatomical determinant. Both models used Firth penalised regression on the same complete-case cohort (n = 358).

^c BMI was categorised using Thai/Asia-Pacific cut-points (normal weight as reference). The category P value is the penalised likelihood-ratio test for BMI as a whole. ^d Preoperative inotropic/vasopressor support was coded as present only when documented; blank entries were treated as no recorded use. ^e Disease location was excluded from the Physiologic model (shaded cells) to assess physiological and surgeon-related predictors without the dominant anatomical effect; VIF analysis did not indicate problematic multicollinearity

Values are adjusted odds ratios (aORs) with 95% penalised Wald CIs. Parent-row P values are penalised likelihood-ratio tests. AIC/BIC were computed from the ordinary log likelihood at Firth estimates and serve as comparative diagnostics only. Bold P values indicate significance at $P < 0.05$.

Abbreviations: AIC, Akaike information criterion; aOR, adjusted odds ratio; ASA, American Society of Anesthesiologists; AUC, area under the receiver operating characteristic curve; BIC, Bayesian information criterion; BMI, body mass index; CI, confidence interval; MPI, Mannheim Peritonitis Index; VIF, variance inflation factor.

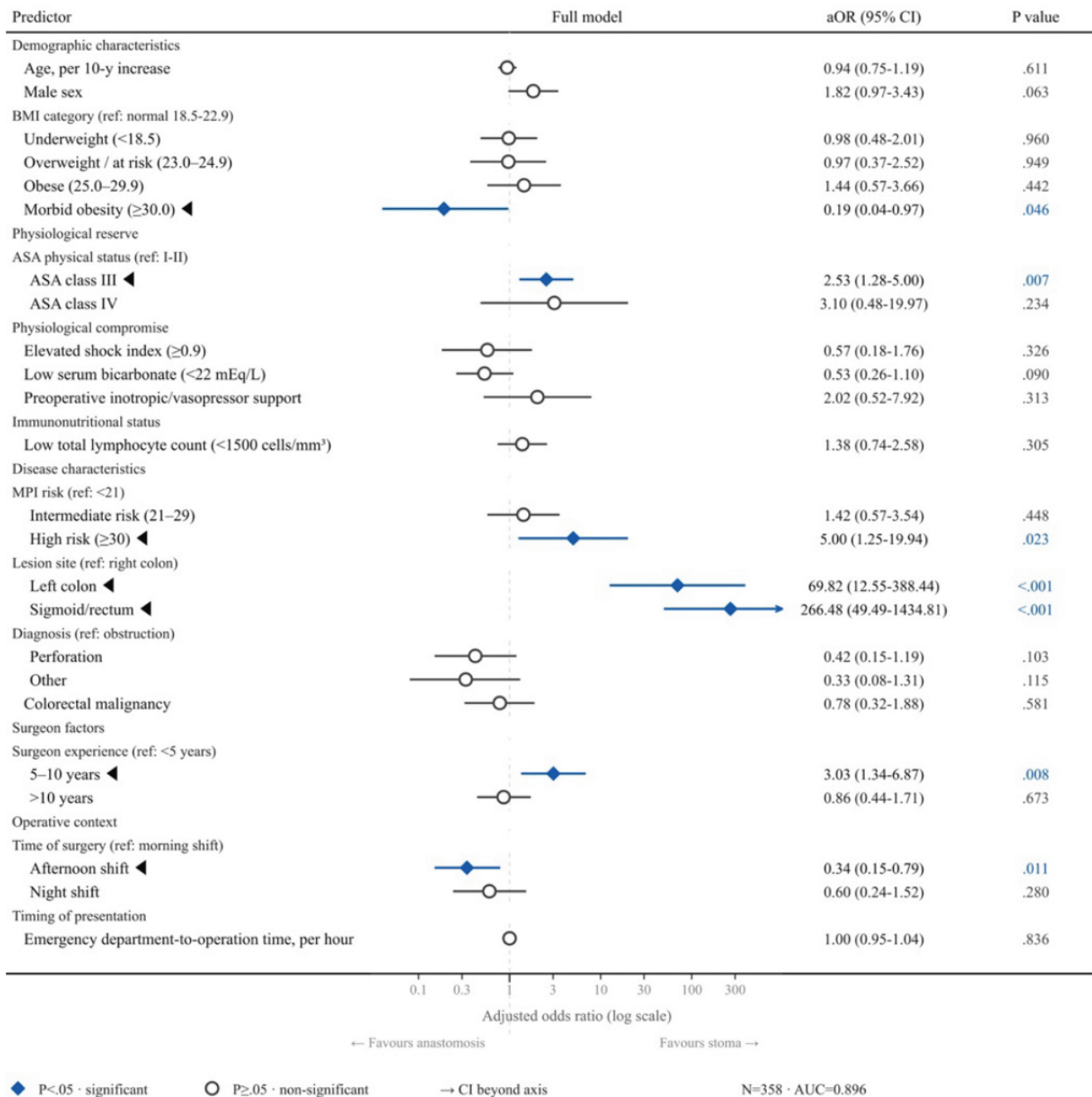


Figure 3 Adjusted predictors of stoma creation in the full multivariable model. Forest plot of adjusted odds ratios (95% penalised Wald CIs) for predictors of stoma creation in the full Firth model, including clinical, physiological, immunonutritional, anatomical, surgeon-related, operative, and timing covariates. Values > 1 indicate higher odds; values <1 indicate lower odds. Disease location showed the strongest association, with markedly higher odds for left-sided and sigmoid/rectal versus right-sided disease. The vertical line indicates an aOR of 1 (abbreviations as in Table 4).

Physiologic Model

Because disease location was the dominant anatomical predictor in the full model, a complementary physiologic model excluding disease location was fitted on the same cohort to evaluate non-anatomical predictors (Table 4), retaining acceptable discrimination (AUC 0.697). ASA class III (aOR 2.32, $P = 0.002$) and high-risk

MPI (aOR 3.01, $P = 0.040$) remained significant independent predictors. Perforation was associated with lower odds than obstruction (aOR 0.39, $P = 0.021$). The surgeon-experience association was attenuated and no longer significant in this model, suggesting part of its apparent full-model effect may reflect anatomical case allocation.

Table 5 Postoperative Outcomes According to Stoma Creation

Outcome	Overall (N = 371)	No stoma (n = 181)	Stoma (n = 190)	Unadjusted OR (95% CI)	<i>P</i> value
Mortality and major outcomes					
30-day mortality	33 (8.9)	17 (9.4)	16 (8.4)	0.89 (0.43-1.81)	0.743
In-hospital mortality	41 (11.1)	19 (10.5)	22 (11.6)	1.12 (0.58-2.14)	0.740
Any postoperative complication	95 (25.6)	42 (23.2)	53 (27.9)	1.28 (0.80-2.05)	0.301
Reoperation	27 (7.3)	10 (5.5)	17 (8.9)	1.68 (0.75-3.77)	0.205
Specific postoperative complications					
Recorded anastomotic leak	25 (6.7)	25 (13.8)	—	—	—
Surgical site infection/visceration	26 (7.0)	14 (7.7)	12 (6.3)	0.80 (0.36-1.79)	0.593
Intra-abdominal collection	33 (8.9)	21 (11.6)	12 (6.3)	0.51 (0.24-1.08)	0.074
Hospital- or ventilator-associated pneumonia	57 (15.4)	24 (13.3)	33 (17.4)	1.38 (0.78-2.43)	0.273
Cardiovascular event	14 (3.8)	7 (3.9)	7 (3.7)	0.95 (0.33-2.77)	0.926
Sepsis	77 (20.8)	38 (21.0)	39 (20.5)	0.97 (0.59-1.61)	0.912
Unable to extubate immediately after surgery	96 (26.1)	36 (20.1)	60 (31.7)	1.85 (1.15-2.98)	0.011
Resource utilization					
ICU admission	105 (28.3)	46 (25.4)	59 (31.1)	1.32 (0.84-2.08)	0.228
ICU length of stay among ICU-admitted patients, d	7.0 (3.0-20.0)	7.5 (3.0-20.0)	7.0 (4.0-20.0)	—	0.766
Hospital length of stay, d	11.0 (8.0-18.0)	10.0 (8.0-17.0)	11.0 (7.0-19.0)	—	0.294
Stoma-related outcomes					
Stoma closure	15/190 (7.9)	—	15 (7.9)	—	—
Stoma not closed at last documented follow-up	175/190 (92.1)	—	175 (92.1)	—	—

Values are No. (%) or median (IQR), as appropriate. Unadjusted odds ratios compare the stoma group with the no-stoma (reference) group.

P values used the χ^2 test or Fisher exact test for categorical outcomes and Mann-Whitney U for continuous outcomes.

In-hospital mortality was defined as 30-day mortality plus later in-hospital death; one patient recorded in both fields was counted once, so the total was 41, not 42. Any postoperative complication was derived from Comp_No_Serious (0 = at least one complication; 1 = no serious complication). Recorded anastomotic leak is presented descriptively (no between-group OR/P value) because anastomosis exposure differed structurally by strategy; there were 25 events in the primary-anastomosis group. ICU length of stay was summarized only among patients with ICU_days > 0. Stoma-related outcomes apply only to the 190 patients with stoma creation; time to closure was not reported due to unavailable closure-time data.

Postoperative Outcomes

Postoperative outcomes are presented in Table 5. Thirty-day mortality was similar between groups (8.4% stoma vs 9.4% anastomosis; $P = 0.743$). Total in-hospital mortality — 33 deaths within 30 days plus 9 late deaths, one patient counted once across both — was 11.1% overall (11.6% vs 10.5%).

Anastomotic leak, assessed in the 181 primary-anastomosis patients, occurred in 25 (13.8%; 95% CI 9.1–19.7). Overall complication rates were comparable (27.9% vs 23.2%; $P = 0.301$). Inability to extubate immediately was significantly more frequent in the stoma group (31.7% vs 19.9%; $P = 0.011$), consistent with greater physiological burden. Hospital length of stay was similar (median 11.0 vs 10.0 days; $P = 0.294$). Resection with anastomosis and protective proximal diversion was performed in only 2 patients (0.5%), both loop ileostomies; neither developed leak and both survived to 30 days, and neither stoma had been closed at last follow-up. Leak rates by operating session among the 181 primary-anastomosis patients were 15.8% (6/38) morning, 13.1% (13/99) afternoon and 14.6% (6/41) night. Median ED-to-operation time was 12 hours for morning and 6 hours for afternoon and night operations.

Stoma-Related Outcomes

Among the 190 patients undergoing stoma creation, documented closure was achieved in

only 15 (7.9%). Among the 175 (92.1%) without closure at last follow-up, the commonest reason was cancer progression/palliative status (65.7%), followed by medical unfitness/high operative risk (18.9%), death before closure (12.0%), loss to follow-up (1.7%), and system/waiting-list delay (1.7%). This indicates a high rate of permanent stoma, attributable largely to malignant aetiology and physiological frailty.

Discussion

Principal Findings

In this decade-long cohort of 371 patients, stoma creation occurred in 190 (51.2%) — substantially higher than our pre-study estimate (~19%) and most published series. Disease location was the dominant determinant: only 1.1% of right-sided cases received a stoma, versus 43.9% left-sided and 75.5% sigmoid/rectal. After adjustment, physiological reserve (ASA), disease severity (MPI), surgeon experience, and operative timing each contributed independently. The full model achieved excellent discrimination (AUC 0.889); a physiologic model excluding disease location retained acceptable discrimination (AUC 0.697), supporting the conclusion that non-anatomical factors carry independent predictive value even without anatomical information.

Comparison With Existing Literature

International data on stoma practice after



emergency colorectal resection are heterogeneous: the GlobalSurg and APOLLO cohorts document wide variation across countries, attributed to surgeon experience, perioperative resources and case mix rather than disease biology alone,^{2,11} while the 2017 WSES guidelines endorse individualised decision-making without specifying which factors should drive it.¹ Our stoma rate sits at the upper end of this range, consistent with the physiologically compromised presentations and limited overnight resources of provincial practice. The anatomical gradient we observed mirrors this pattern and reflects established principles: right-sided anastomoses benefit from more reliable perfusion and lower bacterial load, whereas left-sided and rectosigmoid resections face greater contamination and technical difficulty. The magnitude of this effect produced the quasi-complete separation addressed by Firth regression, explaining the wide confidence intervals around the disease-location estimates.

The independent association between high-risk MPI and stoma creation (aOR 5.00 full model; 3.01 physiologic model) extends the foundational work of Linder and Wacha and of Billing et al,^{16,17} and aligns with Biondo et al's evaluation of MPI in left-sided colonic peritonitis.²² Our findings support that recommendation in a resource-limited population, where limited availability of lactate and albumin necessitated bicarbonate and total lymphocyte count as pragmatic surrogate markers.

ASA status was independently associated with stoma creation in both models, reaffirming that physiological reserve — not only acute derangement — informs the decision. More unexpectedly, morbid obesity (BMI ≥ 30.0 kg/m²) carried markedly lower odds (aOR 0.19). With only 14 such patients the estimate may reflect a small-sample artefact, the obesity paradox reported in colorectal and general surgery,^{23,24} or reluctance to site a stoma in a thick abdominal wall — supported by a French multicentre cohort of emergency obstructive colon cancer surgery in which obese patients had similar overall morbidity but significantly more stoma-related complications when a left-sided stoma was fashioned.²⁵ The finding is statistically fragile: it derives from 3 stoma events among 14 patients, its confidence interval approaches unity, and significance is not retained in the physiologic model. It should be regarded as hypothesis-generating rather than as evidence of a protective effect.

Surgeon experience and operative timing were independent but hypothesis-generating predictors. Experience of 5–10 years compared with < 5 years carried markedly higher odds of stoma creation (aOR 2.83), attenuated after removing disease location — suggesting case allocation, with these surgeons more often managing complex left-sided or septic cases, rather than a lower threshold for diversion. A classic comparison similarly found that non-colorectal-trained surgeons anastomosed



less often, with higher morbidity and mortality, and that trainees anastomosed far more often under colorectal supervision — indicating that specialisation and supervision, not seniority alone, shape this decision.²⁶ Afternoon-shift operations showed lower odds than morning shifts (aOR 0.34). Over half of operations occurred on the afternoon shift, and morning cases had a longer median emergency department-to-operation time than afternoon or night cases (12 vs 6 hours), possibly reflecting local scheduling and case-allocation patterns.²⁷ The effect attenuated in the physiologic model (aOR 0.60), and leak did not vary by session, indicating case allocation rather than resource-driven diversion. Both observations reinforce ACPGBI and WSES calls for structured decision support, particularly for less experienced surgeons operating without subspecialty back-up.^{1,27}

These findings should be read against randomised evidence favouring primary anastomosis in perforated diverticulitis: the Oberkofler, Binda, DIVERTI and LADIES/DIVA trials each showed anastomosis to be safe in stable, carefully selected patients.^{6,7,9,10} All excluded unstable or heavily contaminated patients — precisely the population our model identifies as most likely to receive a stoma. Quantifying the contributions of MPI, ASA and disease location may identify patients in whom anastomosis could reasonably extend beyond trial criteria.

Stoma reversal was infrequent: 15 of 190 patients (7.9%), consistent with the high permanent-stoma burden after emergency colorectal surgery,^{4,5} and lower than the long-term LADIES/DIVA follow-up,⁹ the Gachabayov meta-analysis,²⁸ and dedicated reversal cohorts from Veterans Affairs²⁹ and elderly rectal cancer populations.³⁰ Non-reversal was driven by cancer progression or palliative status (65.7%) and medical unfitness (18.9%), echoing Ketelaers et al,³⁰ and Napolitano et al's identification of ASA class, age and laparoscopic index surgery as predictors of non-reversal.²⁹ Given this cohort's age and malignancy burden, diversion here is, for most patients, tantamount to a permanent stoma, and counselling should be framed accordingly.

Thirty-day mortality did not differ between strategies (8.4% vs 9.4%); this unadjusted observational comparison should not be read as equivalence or as evidence that either strategy was safer. Leak occurred in 25 of 181 patients anastomosed without proximal diversion (13.8%; 95% CI 9.1–19.7), at the higher end of published ranges. Selection would, if anything, have biased this rate downward, since the more favourable patients were chosen for anastomosis; residual confounding nevertheless remains possible. Savitch et al showed that delayed leak recognition triples failure-to-rescue,³ Ochs et al that machine-learning models can flag high-risk patients,³¹ and



a recent large-bowel-obstruction review identifies male sex, obesity, comorbidity and prolonged operative duration as leak risk factors overlapping ours.³² These echo an Acute Care Surgery series in which pre-existing cardiac disease and clinical perforation, rather than operative time or blood loss, were the strongest mortality predictors — reinforcing that physiological and disease-severity status, not technical conduct, chiefly determine risk here.³³

WSES guidance conditions primary anastomosis on physiological reserve and on the capacity to rescue a failed anastomosis,¹ and treats local operating conditions, alongside patient and disease factors, as legitimate determinants of whether to divert.³⁴ Meta-analytic evidence, although derived from elective rectal surgery, indicates that proximal diversion reduces not only leak but also reoperation — the outcome most sensitive to rescue capacity.³⁵ Both reserve and rescue capacity are attenuated here: no colorectal subspecialty input at the index operation and no continuous intensivist cover. Our model predicts the decision to divert rather than anastomotic leakage and should not be interpreted prescriptively. The observed 13.8% leak rate nevertheless underlines the importance of timely leak detection and

adequate rescue capacity. Protective diversion was used in only 0.5% of this cohort, indicating that operative strategy functioned largely as a binary choice between anastomosis and end stoma; whether wider use of protective diversion would improve outcomes in this setting requires prospective evaluation.

Clinical and Practical Implications

These findings support a structured, locally validated decision framework combining MPI, ASA status and disease location to guide — not replace — surgical judgement, particularly for less experienced surgeons without subspecialty support (Figure 4), aligned with ACPGBI/WSES calls for standardisation^{1,27} and complementary to leak-prediction tools such as that of Ochs et al.³¹ Because core staff performed most operations while visiting on-call surgeons covered a smaller share, a shared protocol could align the diversion threshold across both groups. Given how rarely stomas are reversed, patients and families should be counselled preoperatively that reversal is unlikely, and follow-up pathways should identify the minority — typically younger, with non-malignant disease and preserved physiological reserve — who are realistic candidates for it.

Conceptual framework for emergency ostomy creation outcomes in a provincial hospital

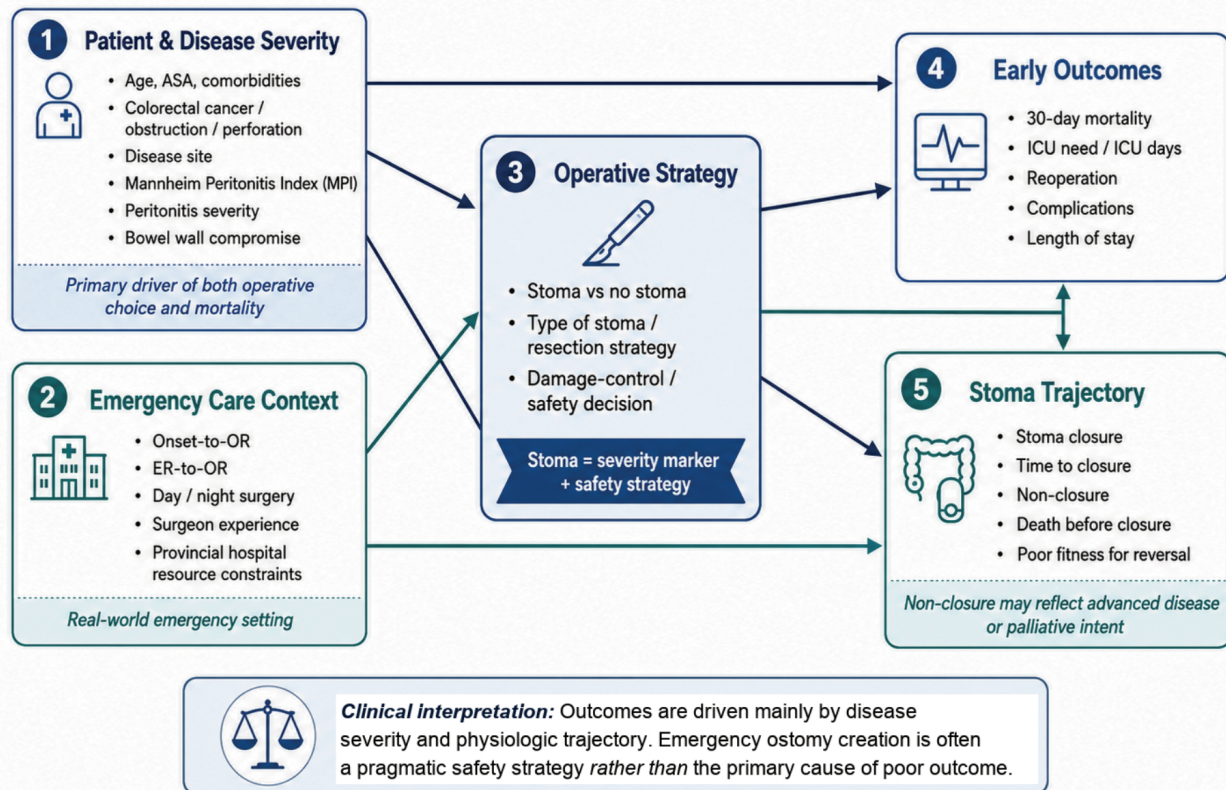


Figure 4 Conceptual framework linking patient/disease severity and emergency-care context, through the operative strategy decision, to early outcomes and stoma trajectory in a provincial hospital setting.

Strengths and Limitations

This study is among the few to characterise the determinants of the stoma-creation decision itself — rather than outcomes or technique — in a resource-limited provincial setting; a PubMed and Scopus search (July 2026) identified no comparable provincial series. It uses ten years of consecutive, unselected data and a pre-specified covariate set spanning eight domains, and Firth

penalised regression with a complementary physiologic model gave stable estimates despite quasi-complete separation while isolating non-anatomical contributions.

Several limitations apply. This retrospective, single-centre study may not generalise to hospitals with different staffing, case mix or referral patterns. Missingness in lactate (97%) and albumin (39.1%) necessitated surrogate markers and complete-case



analysis (358/371), which may have introduced selection bias if missingness was not random. The strong effect of disease location produced wide confidence intervals, indicating a robust direction rather than a precise effect size. The decade-long period spans substantial secular change — publication of the 2017 WSES guidelines,¹ evolving surgeon case-mix and COVID-19 disruption of surgical services (2020–2021) — and calendar year could not be entered alongside surgeon experience without collinearity, so residual secular confounding cannot be excluded. Caseload was imbalanced across the 14 surgeons (1–82 cases each), raising the possibility of unmodelled within-surgeon clustering. Intraoperative surgeon judgement, patient or family preference and formal frailty assessment were unavailable. Finally, stoma closure was tracked only within our institution; as in the Veterans Affairs experience, some patients may have undergone reversal elsewhere and been misclassified, so the 7.9% closure rate should be regarded as a conservative estimate.²⁹ The morbid-obesity subgroup comprised only 14 patients with 3 stoma events; the corresponding estimate is unstable across model specifications and should not be used to inform practice.

Conclusion

In a decade of emergency colorectal practice at a resource-limited provincial hospital in southern Thailand, stoma creation occurred in

just over half of patients, driven predominantly by disease location, disease severity (MPI) and physiological reserve (ASA status), with secondary contributions from surgeon experience and operative timing. Postoperative mortality did not differ by strategy, but stoma reversal was achieved in fewer than 1 in 12 patients — meaning the decision to divert is, for most patients, effectively a decision for a permanent stoma. These findings support locally adapted, objective decision-support frameworks and realistic preoperative counselling on reversal likelihood in resource-limited surgical environments.

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Conflict of Interest

The author declares no conflict of interest.

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Author Contributions: T.P. (sole author): study conception and design, ethical approval, data collection and abstraction, statistical analysis, interpretation, and manuscript preparation.

Data Availability

The dataset analysed is not publicly available due to institutional and patient confidentiality restrictions but may be available from the corresponding author on reasonable request, subject to institutional approval.

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