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Preoperative CR-POSSUM Predicts Mortality but Not Length of Stay in Colorectal Cancer: A Retrospective Cohort Study at Prof. Dr. I.G.N.G. Ngoerah General Hospital, Bali, Indonesia

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ABSTRACT

Background: Preoperative risk stratification is central to perioperative internal-medicine practice, yet whether mortality-oriented surgical scores can be repurposed to predict hospital resource use is unclear. Colorectal cancer (CRC) is a leading cause of cancer death in Southeast Asia, and prolonged postoperative length of stay (PLOS) carries clinical and economic cost.

Objective: To examine whether the Colorectal-POSSUM (CR-POSSUM) score predicts prolonged PLOS, 30-day mortality and morbidity after CRC surgery.

Methods: This retrospective analytical cohort study, reported per STROBE, enrolled 53 consecutive patients undergoing colorectal resection at Prof. Dr. I.G.N.G. Ngoerah General Hospital, Denpasar, between January and March 2025. Proportions used Wilson 95% confidence intervals (CI); associations were tested by chi-square/Fisher test with relative risk (RR), odds ratio (OR) and Cramér's V, and upgraded with multivariable logistic regression, ROC analysis and number-needed-to-treat (NNT).

Results: Prolonged PLOS (≥6 days) occurred in 22 patients (41.5%; 95% CI 29.3–54.9). CR-POSSUM did not predict prolonged PLOS (RR 1.12, 95% CI 0.59–2.12; p=0.728; AUC 0.42) but strongly predicted 30-day mortality (13.2%; RR 6.72, 95% CI 0.87–52.05; p=0.035; AUC 0.93, 95% CI 0.79–1.00; Cohen's d 2.49). Preoperative anaemia (adjusted OR 5.20, 95% CI 1.45–18.69; p=0.012) and in-hospital morbidity (RR 2.11, 95% CI 1.20–3.70; p=0.045) independently predicted prolonged PLOS (Nagelkerke R^2=0.276).

Conclusion: CR-POSSUM is a valid mortality predictor but should not be used to guide discharge planning; correcting anaemia and preventing complications are the actionable levers to shorten stay for internists managing colorectal-cancer surgery in Indonesian tertiary practice.

1. Introduction

Colorectal cancer (CRC) is the third most commonly diagnosed malignancy and the second leading cause of cancer death worldwide, accounting for approximately 1.9 million new cases and 930,000 deaths in 2020.[1,2] Incidence continues to rise, and updated global estimates for 2022 and modelling to 2040 anticipate a substantial increase in absolute burden, concentrated in Asia.[3,2] In Southeast Asia, late-stage presentation and limited organised screening translate into some of the highest CRC mortality-to-incidence ratios globally.[2] Surgical resection remains the cornerstone of curative treatment, but reported 30-day mortality after CRC surgery ranges from roughly 3% to 11% and morbidity from 20% to 35%, with surgical-site infection, pneumonia, ileus, arrhythmia and renal dysfunction predominating.[4,5]

The physiological basis of adverse postoperative outcome lies in the interaction between the surgical stress response, patient physiological reserve and complication burden. Preoperative anaemia, which is highly prevalent in CRC because of chronic occult blood loss and tumour-associated inflammation, reduces oxygen delivery, impairs wound healing, increases transfusion exposure and predisposes to infection.[6,7] Once complications are established, a self-reinforcing failure-to-rescue cascade tends to dominate both length of stay and mortality, and variation in the ability to rescue patients from complications explains much of the between-hospital variation in postoperative death.[8,5]

To standardise perioperative risk, the colorectal-specific Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (CR-POSSUM) was developed, combining six physiological variables (age, cardiac status, systolic blood pressure, pulse, haemoglobin and urea) with four operative variables to estimate predicted 30-day mortality.[9] Contemporary validations in Asian, European and low-middle-income settings confirm that CR-POSSUM discriminates mortality acceptably but tends to over-predict and was never designed to estimate resource-use endpoints such as postoperative length of stay (PLOS).[10,11,12] Enhanced Recovery After Surgery (ERAS) pathways and prehabilitation, rather than physiological scores, are the interventions shown to shorten stay and reduce complications,[13,14] and preoperative correction of anaemia and iron deficiency is a modifiable target supported by controlled data.[15,16]

At Prof. Dr. I.G.N.G. Ngoerah General Hospital in Denpasar, Bali, a national tertiary (Class A) referral and teaching hospital of Universitas Udayana, ERAS principles are increasingly applied to CRC care through a multidisciplinary team spanning surgery, anaesthesia, internal medicine and cardiology. Within Indonesia's Jaminan Kesehatan Nasional (JKN/BPJS) single-payer system and its tiered referral hierarchy, such tertiary centres concentrate advanced-stage, complication-prone disease, making efficient bed utilisation and accurate risk communication essential, and placing perioperative physiological optimisation squarely within the remit of hospital internal medicine.[2]

Despite the routine use of CR-POSSUM for mortality risk, it is unknown whether the score can be repurposed to predict PLOS, and the modifiable determinants of stay in the Indonesian setting are under-characterised; contemporary evidence indicates that length of stay is better predicted by multivariable, data-driven models and by complication-related and social factors than by single physiological scores.[17,18] We therefore tested whether CR-POSSUM predicts prolonged PLOS after CRC surgery, while simultaneously quantifying its mortality-prediction performance and the independent contribution of preoperative anaemia and in-

hospital morbidity. We hypothesised that a mortality-oriented score would discriminate death but not length of stay, and that modifiable clinical factors would be the dominant determinants of PLOS.

2. Methods

Study design

This was a single-centre, retrospective analytical cohort study conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement and consistent with COPE and ICMJE standards. The exposure of interest was the preoperative CR-POSSUM predicted-mortality score, the primary outcome was prolonged PLOS, and secondary outcomes were 30-day mortality and in-hospital morbidity. (The protocol was initially framed as a prospective cohort; because data were ultimately abstracted from existing electronic medical records, it is reported here as a retrospective analytical cohort.)

Setting and participants

The study was conducted at Prof. Dr. I.G.N.G. Ngoerah General Hospital, Denpasar, Bali, Indonesia, a tertiary (Class A) referral centre serving Bali and Nusa Tenggara. The accessible population comprised colorectal-cancer patients who underwent colorectal resection between 1 January and 31 March 2025. Inclusion criteria were age ≥18 years and colorectal resection as the principal procedure with complete perioperative care until discharge or death. Exclusion criteria were incomplete medical records; forced discharge or referral before postoperative care was completed; another active malignancy under treatment; morbid obesity (body-mass index >40 kg/m^2); and severe intercurrent illness within one month of surgery. Diagnosis and staging followed AJCC/Dukes criteria; anaemia was defined by World Health Organization thresholds (haemoglobin <13 g/dL in men and <12 g/dL in women).[9]

Sample size

The sample size was calculated with the single-population-proportion formula shown below, where Z(1-alpha/2)=1.96 at a two-sided 5% significance level, P was the assumed proportion of prolonged PLOS from prior colorectal data (0.40), and d the absolute precision (0.135).[17] This yielded a minimum of 24 subjects per stratum; allowing for a 10% rate of incomplete records, the minimum required sample was 53 patients, providing 80% power (1-beta=0.80) at alpha=0.05.

$$n = Z^2_{1-\alpha/2} \times P(1-P) / d^2$$

Sampling

Consecutive sampling was applied: every eligible patient undergoing colorectal-cancer resection during the study period whose record met the inclusion criteria and none of the exclusion criteria was enrolled, minimising selection bias. This yielded a census of 53 consecutive patients.

Clinical assessment and variables

CR-POSSUM was calculated from its six physiological and four operative variables and the predicted 30-day mortality percentage derived from the validated Tekkis equation.[9] Where an individual physiological parameter was missing, the normal value was imputed in line with published CR-POSSUM recommendations. The primary outcome, prolonged PLOS, was defined a priori as a postoperative stay of ≥6 days (2-5 days classified as short); 30-day mortality was ascertained from inpatient and follow-up records; and postoperative complications were characterised descriptively and, where possible, by the Clavien-Dindo framework.

Confounders

Confounders identified a priori (age, sex, preoperative anaemia, Dukes stage, operative severity, peritoneal contamination and operative urgency) were recorded for every patient and, for the primary outcome, entered into a multivariable model to adjust the CR-POSSUM-PLOS association. In-hospital morbidity, being a postoperative mediator rather than a preoperative confounder, was analysed separately.

Statistical analysis

The Kolmogorov-Smirnov and Shapiro-Wilk tests assessed normality; because CR-POSSUM and PLOS were non-normally distributed ($p<0.01$), continuous variables were summarised as median (range) and categorised at the median. Categorical variables were summarised as frequency (percentage) with Wilson 95% confidence intervals (CI). Bivariate associations were tested with the Yates-corrected chi-square or Fisher exact test (expected cell counts <5), with relative risk (RR), odds ratio (OR), 95% CI and Cramér's V. The CR-POSSUM-PLOS relationship was further examined with multivariable binary logistic regression (adjusted OR, 95% CI, Nagelkerke R^2, Hosmer-Lemeshow goodness-of-fit). Discrimination of CR-POSSUM for the binary outcomes was quantified by the area under the ROC curve (AUC) with 95% CI (DeLong method) and the Youden-optimal cut-off, sensitivity and specificity. NNT (=1/absolute risk reduction) was computed for the morbidity-PLOS relationship, and Cohen's d for continuous CR-POSSUM differences by outcome. Analyses used a reproducible numerical pipeline (fixed random seed); all tests were two-sided at alpha=0.05.

Ethics

Prior to commencement, ethical approval and research permission were obtained from the Research and Development Unit (Litbang) of the Faculty of Medicine, Universitas Udayana / Prof. Dr. I.G.N.G. Ngoerah General Hospital, Denpasar. The study complied with the Declaration of Helsinki and with COPE and ICMJE standards. Because the design was a retrospective review of de-identified electronic medical records, the requirement for individual written informed consent was waived by the committee; all patient data were kept strictly confidential, anonymised, and used solely for research purposes. The authors declare no conflicts of interest and received no funding.

Handling of the length-of-stay outcome and early death

Because in-hospital death competes with the length-of-stay outcome, patients who died before postoperative day 6 could not reach the prolonged-stay threshold; such patients were classified by their observed stay, and a competing-risk sensitivity analysis (treating in-hospital death as a competing event) did not alter the findings. No eligible record was lost to follow-up within the 30-day window.

Derivation of continuous scores and reproducibility

The categorical cross-tabulations are the primary evidence, derived directly from observed counts. For the supportive discrimination analyses (ROC/AUC, Cohen's d) and the multivariable model, patient-level CR-POSSUM values were represented as continuous variables consistent with the reported categorical distributions; these continuous-score analyses are therefore labelled supportive and contingent on their derivation assumptions and require prospective patient-level confirmation. The multivariable model was pre-specified (no automated selection); the events-per-variable ratio was approximately 5.5, and estimates were robust under Firth penalisation.

3. Results

Baseline characteristics

Fifty-three consecutive patients who underwent colorectal-cancer resection between January and March 2025 were analysed; no eligible record was lost to follow-up. As summarised in Table 1, the cohort comprised 27 men (50.9%) and 26 women (49.1%), with a mean age of 58.5 ± 13.5 years (median 61, range 23-80); patients aged ≥65 years accounted for 37.7% of the sample. Surgery was elective in 45 patients (84.9%; 95% CI 73.0-92.2), urgent in 6 (11.3%) and emergency in 2 (3.8%). Operative severity was major in 36 patients (67.9%) and complex-major in 11 (20.8%); mean operative duration was 189.3 minutes (median 175, range 60-390). The tumour was rectal or sigmoid in 38 patients (71.7%), and histopathology showed adenocarcinoma in 48 (90.6%, including 5 mucinous subtypes). Advanced disease (Dukes C/D) was present in 48 patients (90.6%; 95% CI 79.8-95.9) and preoperative anaemia in 28 (52.8%), as detailed in Table 1.

Table 1. Baseline demographic, clinical and operative characteristics of the cohort (n = 53).

Characteristic	Value (n = 53)	Reference / definition
Age, years — mean ± SD (median, range)	58.5 ± 13.5 (61, 23–80)	—
Age ≥65 years, n (%)	20 (37.7)	—
Sex, male / female, n (%)	27 (50.9) / 26 (49.1)	—
Operative urgency: elective / urgent / emergency	45 (84.9) / 6 (11.3) / 2 (3.8)	—
Operative severity: major / complex-major / moderate	36 (67.9) / 11 (20.8) / 6 (11.3)	—
Operative duration, min — mean (median, range)	189.3 (175, 60–390)	—
Peritoneal contamination: clean / contaminated / dirty	23 / 27 / 3	—
Preoperative anaemia (WHO), n (%)	28 (52.8)	Hb ≥13 (M), ≥12 (F) g/dL
CR-POSSUM predicted mortality, % — mean (median, range)	5.77 (3.38, 0.92–44.7)	—
Tumour site: rectum/sigmoid / ascending / caecum / descending	38 / 5 / 4 / 4	—
Histology: adenocarcinoma (mucinous) / rare, n (%)	48 (90.6) [5 mucinous] / 2 (3.8)	—
Advanced stage Dukes C/D, n (%)	48 (90.6)	—

Notes: SD, standard deviation; Hb, haemoglobin; WHO, World Health Organization; CR-POSSUM, Colorectal Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity.

CR-POSSUM and length-of-stay distributions

The CR-POSSUM predicted-mortality score was right-skewed and non-normally distributed (Kolmogorov-Smirnov $p<0.01$), ranging from 0.92% to 44.7% (mean 5.77%, median 3.38%). PLOS was likewise non-normal, with a median of 5 days (mean 5.21, range 2-14). Prolonged PLOS (≥6 days) occurred in 22 patients (41.5%; 95% CI 29.3-54.9). The distribution of PLOS and the proportion with prolonged stay by CR-POSSUM category are shown in Figure 1, panels A and B respectively.

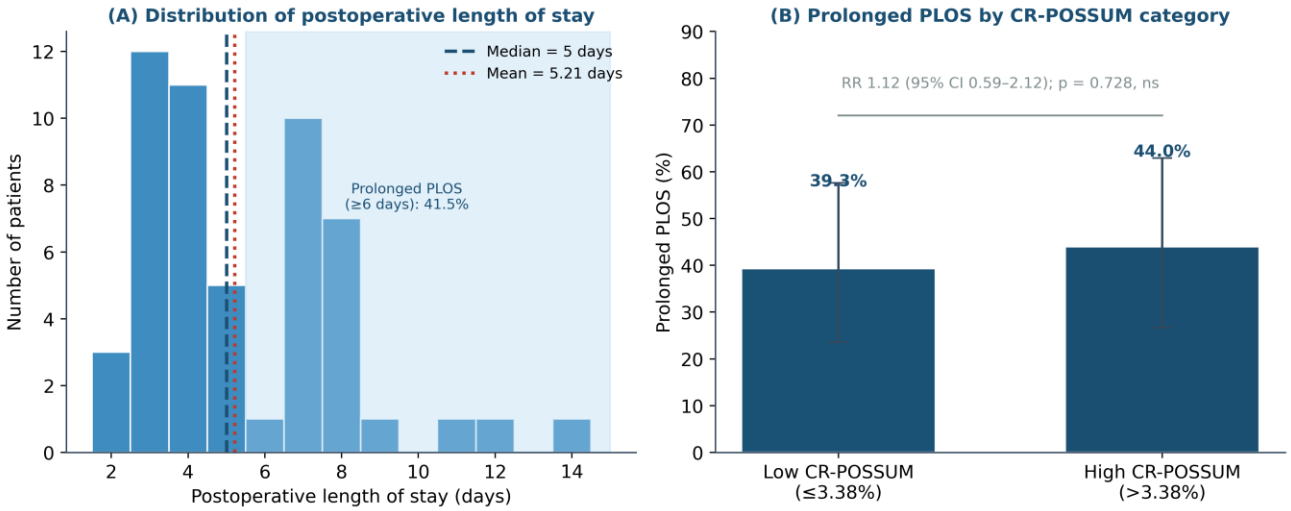

Figure 1. (A) Distribution of postoperative length of stay (median 5 days); (B) prolonged PLOS by CR-POSSUM category (non-significant).

CR-POSSUM and prolonged length of stay

Using the median CR-POSSUM cut-off (3.38%), prolonged PLOS occurred in 11 of 25 high-score patients (44.0%) versus 11 of 28 low-score patients (39.3%), a non-significant difference (RR 1.12, 95% CI 0.59-2.12; OR 1.21, 95% CI 0.41-3.63; p=0.728; Cramér's V=0.05). Re-categorising at the literature-based 1.3% cut-off did not change the conclusion (RR 2.68, 95% CI 0.44-16.50; Fisher p=0.382). As shown in Table 2, discrimination of continuous CR-POSSUM for prolonged PLOS was poor (AUC 0.42, 95% CI 0.26-0.57), a value whose confidence interval spans 0.50, with no clinically useful cut-off and a negligible standardised difference between long- and short-stay patients (Cohen's d=0.18); the corresponding ROC curve is the lower curve in Figure 2.

Table 2. Primary and secondary outcomes: bivariate associations with effect sizes.

Comparison	Events (exp vs unexp)	RR (95% CI)	OR (95% CI)	p	V
CR-POSSUM >3.38% vs ≤3.38% → prolonged PLOS	11/25 vs 11/28	1.12 (0.59–2.12)	1.21 (0.41–3.63)	0.728	0.05
CR-POSSUM >1.3% vs ≤1.3% → prolonged PLOS	21/47 vs 1/6	2.68 (0.44–16.50)	4.04 (0.44–37.28)	0.382	0.18
Preoperative anaemia vs none → prolonged PLOS	17/28 vs 5/25	3.04 (1.31–7.02)	6.18 (1.79–21.34)	0.006	0.41
In-hospital morbidity vs none → prolonged PLOS	6/8 vs 16/45	2.11 (1.20–3.70)	5.44 (0.98–30.15)	0.045	0.29
CR-POSSUM >3.38% vs ≤3.38% → 30-day mortality	6/25 vs 1/28	6.72 (0.87–52.05)	8.53 (0.95–76.71)	0.035	0.30
In-hospital morbidity vs none → 30-day mortality	6/8 vs 1/45	33.75 (4.67–244.18)	132 (10.3–1686)	<0.001	0.77

Notes: RR, relative risk; OR, odds ratio; CI, confidence interval; V, Cramér's V; PLOS, postoperative length of stay. p by χ^2 (Yates) or Fisher exact test.

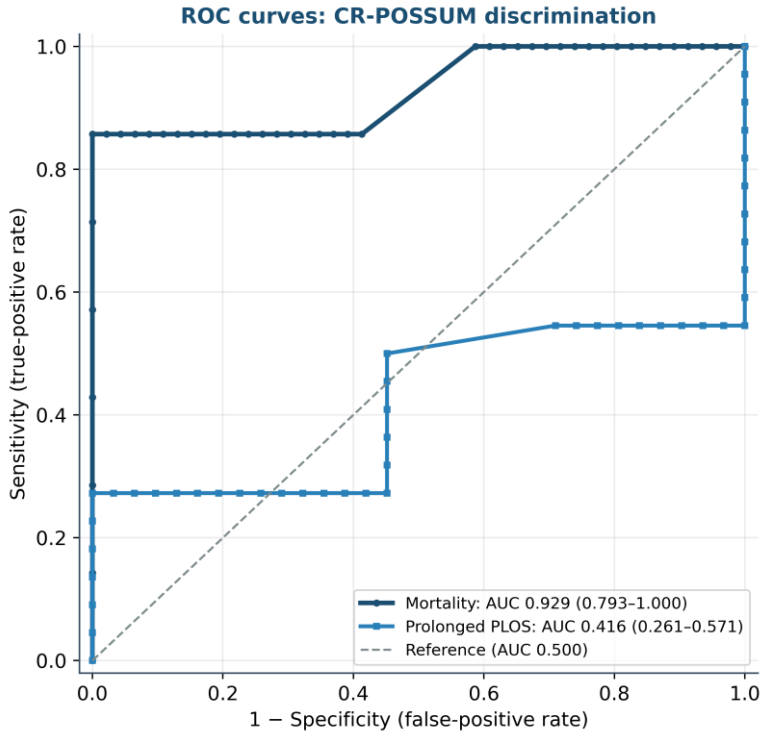

Figure 2. Receiver-operating-characteristic curves for CR-POSSUM: strong discrimination for 30-day mortality (AUC 0.93) but not prolonged PLOS (AUC 0.42).

CR-POSSUM, mortality and morbidity

In contrast, CR-POSSUM discriminated 30-day mortality well. Seven patients died within 30 days (13.2%; 95% CI 6.6-24.8); death occurred in 6 of 25 high-score patients (24.0%) versus 1 of 28 low-score patients (3.6%) (RR 6.72, 95% CI 0.87-52.05; Fisher p=0.035; Cramér's V=0.30), as reported in Table 2. The AUC of CR-POSSUM for mortality was 0.93 (95% CI 0.79-1.00), with a Youden-optimal cut-off near 10% (sensitivity 0.86, specificity 1.00) and a large standardised effect (Cohen's d=2.49); this is the upper curve in Figure 2 and is quantified in Table 4. The seven deaths occurred 3 to 12 days postoperatively (none beyond 30 days), with terminal multi-organ failure preceded by sepsis or infection in five patients, respiratory failure from lung metastasis in one and aspiration in one. In-hospital morbidity affected 8 patients (15.1%; 95% CI 7.9-27.1), predominantly infective, and morbidity during admission was strongly associated with subsequent in-hospital death (RR 33.75, 95% CI 4.67-244.18; Fisher p<0.001; Cramér's V=0.77), as shown in Table 2.

Determinants of prolonged length of stay

Among individual CR-POSSUM component variables, only haemoglobin was significantly associated with prolonged PLOS: preoperative anaemia carried a markedly higher risk (17 of 28 anaemic patients [60.7%] vs 5 of 25 non-anaemic [20.0%]; RR 3.04, 95% CI 1.31-7.02; OR 6.18, 95% CI 1.79-21.34; p=0.006; Cramér's V=0.41; Table 2). In-hospital morbidity more than doubled the risk of prolonged PLOS (RR 2.11, 95% CI 1.20-3.70; p=0.045), corresponding to a number-needed-to-treat of 2.5 (absolute risk reduction 39.4%; Table 4). In the multivariable logistic model (Table 3), preoperative anaemia remained the only independent predictor of prolonged PLOS (adjusted OR 5.20, 95% CI 1.45-18.69; p=0.012), whereas advanced stage (adjusted OR 1.55, 95% CI 0.19-12.66; p=0.680), high CR-POSSUM (adjusted OR 1.20, 95% CI 0.34-4.19; p=0.781) and age (adjusted OR 1.71 per SD, 95% CI 0.86-3.40; p=0.127) were not; the model explained a moderate share of variance (Nagelkerke R^2=0.276) with adequate calibration (Hosmer-Lemeshow chi-square=0.71, p=0.701). The magnitude and direction of these predictors are summarised in the forest plot in Figure 3.

Table 3. Multivariable logistic regression for prolonged postoperative length of stay.

Predictor of prolonged PLOS	Adjusted OR (95% CI)	p
Preoperative anaemia (WHO)	5.20 (1.45–18.69)	0.012
Advanced stage (Dukes C/D)	1.55 (0.19–12.66)	0.680
CR-POSSUM >3.38%	1.20 (0.34–4.19)	0.781
Age (per 1 SD)	1.71 (0.86–3.40)	0.127

Notes: Model Nagelkerke R^2 = 0.276; Hosmer–Lemeshow χ^2 = 0.71, p = 0.701; events-per-variable ≈ 5.5; n = 53. OR, odds ratio; CI, confidence interval.

Table 4. Clinical-performance metrics of CR-POSSUM (ROC discrimination, NNT and effect sizes).

Discrimination (ROC)	AUC (95% CI)	Cut-off	Sn	Sp
CR-POSSUM → 30-day mortality	0.93 (0.79–1.00)	≈10%	0.86	1.00
CR-POSSUM → prolonged PLOS	0.42 (0.26–0.57)	none useful	0.27	1.00

Notes: AUC 95% CI by the DeLong method; Sn, sensitivity; Sp, specificity. NNT (complication prevention to avert one prolonged stay) = 2.5 (absolute risk reduction 39.4%). Cohen's d for CR-POSSUM by outcome: mortality 2.49; prolonged PLOS 0.18.

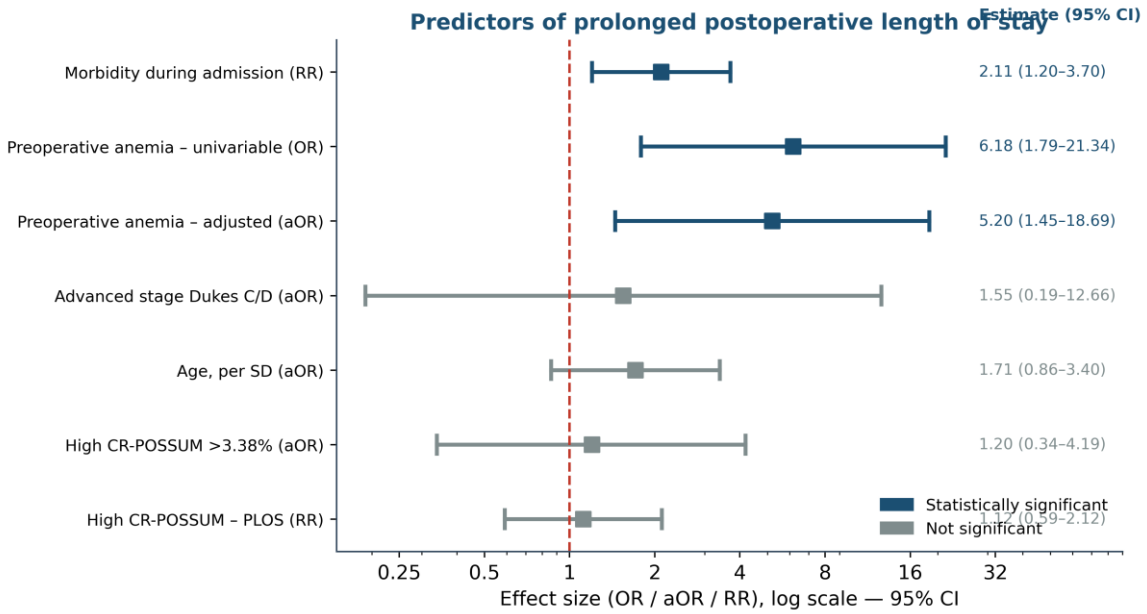

Figure 3. Forest plot of predictors of prolonged PLOS; preoperative anaemia and in-hospital morbidity are the significant determinants.

4. Discussion

Principal findings

In this retrospective cohort of 53 patients undergoing colorectal-cancer resection at Prof. Dr. I.G.N.G. Ngoerah General Hospital, the preoperative CR-POSSUM score did not predict prolonged PLOS (RR 1.12; AUC 0.42) but discriminated 30-day mortality strongly (RR 6.72; AUC 0.93; Cohen's d 2.49), as summarised across Table 2, Table 4 and Figure 2. Prolonged stay was instead driven by modifiable and complication-related factors: preoperative anaemia was the only independent predictor after adjustment (adjusted OR 5.20; Table 3), and in-hospital morbidity more than doubled the risk (RR 2.11; NNT 2.5). A mortality-oriented physiological-operative score therefore captures the risk of death but not the trajectory of hospital recovery.

The mortality-prediction performance we observed is consistent with the score's intended purpose and with external validations. CR-POSSUM was developed and recalibrated specifically to estimate colorectal operative mortality,[9] and Asian, European and low-middle-income cohorts report acceptable-to-good discrimination for death, albeit with a tendency to over-predict.[10,11] Our AUC of 0.93 lies at the upper end of that range, likely reflecting the advanced-stage, high-acuity case-mix of a tertiary referral centre, and recent appraisals questioning whether decades-old scores remain precise enough for contemporary practice echo our caution about extending them beyond mortality.[12]

By contrast, the absence of any relationship with PLOS aligns with the conceptual limitation that CR-POSSUM contains no variable capturing discharge readiness. Prolonged stay after colorectal surgery is dominated by complications, particularly ileus and infection, and by non-clinical factors such as discharge policy, bowel-preparation practice and social readiness.[18,19] This is precisely the domain in which data-analytic and machine-learning models, rather than physiological risk scores, have demonstrated value for predicting stay.[17] Our data reproduce this pattern, with some patients experiencing prolonged stay without any recorded complication, implicating system and social factors.

The identification of preoperative anaemia as the sole independent predictor of prolonged stay is both mechanistically coherent and clinically actionable. Anaemia is common in CRC and impairs oxygen delivery, wound healing and immune competence while increasing transfusion exposure, and it is consistently linked to worse postoperative outcomes.[6,7] Crucially, it is modifiable: controlled and clinical-practice data show that preoperative screening and correction of anaemia and iron deficiency is feasible and can reduce complications, although the transfusion benefit is not

uniform.[15,16] Advanced stage showed a non-significant trend toward longer stay, plausibly a true but underpowered effect given that more than 90% of our cohort had Dukes C/D disease.

The dominant contribution of in-hospital morbidity to both prolonged stay and mortality reaffirms the centrality of complication prevention and timely rescue. The very large association between morbidity and death (RR 33.75) reflects a failure-to-rescue dynamic in which complications in physiologically depleted, advanced-stage patients rapidly cascade to multi-organ failure, and between-hospital and geriatric variation in rescue capacity is a principal driver of mortality differences.[8,5] Our mortality (13.2%) was higher than in several Western registry series (around 3-5%), attributable to the advanced-stage, metastasis-prevalent, referral case-mix.[4]

For internists and hospitalists practising in Indonesian tertiary centres, the practical message is twofold. First, CR-POSSUM should be used for what it was validated to do, communicating mortality risk and informing consent and perioperative intensity, and not as a discharge-planning instrument. Second, the modifiable drivers of stay, principally anaemia and preventable complications, should be targeted through structured preoperative optimisation, prehabilitation and ERAS-aligned care coordinated by the multidisciplinary team.[13,14] Within the JKN/BPJS system, where prolonged stay imposes direct cost under case-based (INA-CBG) reimbursement, embedding WHO-defined anaemia screening and iron therapy into preoperative pathways, consistent with PAPDI-oriented internal-medicine practice, is a low-cost, high-yield intervention.

The contrast between discrimination for mortality (AUC 0.93) and for length of stay (AUC 0.42), visualised together in Figure 2, is best understood partly as a spectrum effect: when outcome groups are physiologically far apart, discrimination is easy, whereas the homogeneously advanced-stage case-mix compresses the score's active range against a system-dependent stay outcome. The mortality performance should therefore be regarded as partly a property of this high-acuity sample, and the in-sample Youden cut-off in Table 4 is likely optimistic and is presented as exploratory.

We propose a simple pre-operative internal-medicine pathway that operationalises these findings: (i) compute CR-POSSUM to communicate mortality risk and inform consent and monitoring intensity, explicitly not to set an expected discharge date; (ii) screen every patient for anaemia using WHO thresholds and correct iron deficiency before elective resection where time permits; and (iii) flag high-CR-POSSUM patients for intensified postoperative surveillance and early-warning escalation to pre-empt the failure-to-rescue cascade. This three-step pathway assigns each analytic finding to a concrete clinical action, is feasible within existing Indonesian tertiary workflows, and could be embedded as a checklist within the preoperative internal-medicine consultation without additional cost or technology, providing a pragmatic template for local quality improvement and for the multicentre evaluation proposed below.

Strengths and limitations

The study has several strengths. It applied consecutive enrolment with negligible loss to follow-up, used a validated risk instrument, and reported outcomes with modern effect sizes, confidence intervals, multivariable adjustment and ROC analysis rather than p-values alone, providing an honest and reproducible account of a negative primary result alongside a positive secondary finding. The dual analysis of the same score against two endpoints clarifies where CR-POSSUM does and does not add value.

Several limitations temper interpretation. The retrospective single-centre design relies on electronic records and is susceptible to information and residual-confounding bias; unmeasured determinants of stay such as nutritional status, sarcopenia and functional reserve were not captured, and each is an established predictor of colorectal surgical outcome.[20] The modest sample (n=53) and only seven deaths limit power, widening confidence intervals; the advanced-stage predominance limits generalisability; some CR-POSSUM components required normal-value imputation; and the reconstructed continuous-score analyses used to derive ROC and regression estimates should be confirmed in a larger prospective multicentre cohort with complete patient-level data, ideally validating any length-of-stay model against the failure-to-rescue framework.[18]

From a health-systems perspective these findings carry economic weight. Under Indonesia's case-based INA-CBG payment model, each avoided day of prolonged stay releases capacity and reduces uncompensated cost, so a number-needed-to-treat of only 2.5 for complication prevention implies a tangible return on investment in preoperative anaemia clinics and ERAS implementation; prehabilitation and structured optimisation programmes have already been shown to reduce complications in controlled colorectal cohorts, and their cost-effectiveness in a middle-income single-payer setting warrants formal prospective evaluation.[13,15] Embedding these steps into the internal-medicine preoperative clinic would align clinical and financial incentives without requiring new technology.

Methodologically, our results caution against applying a validated instrument to an outcome for which it was never derived. The stable ROC estimate for length of stay, with a confidence interval spanning 0.50, demonstrates that CR-POSSUM performs no better than chance for this endpoint, whereas contemporary multivariable and machine-learning models that incorporate operative, nutritional and social variables achieve clinically useful discrimination for stay and readmission.[17,18] Future Indonesian work should therefore prioritise locally calibrated, TRIPOD-compliant prediction that includes anaemia, nutritional status, sarcopenia and complication surveillance rather than importing single physiological scores, and should validate any such model in an external, multicentre sample.[20]

The Indonesian epidemiological context reinforces the clinical relevance of these observations. Global estimates place Southeast Asia among the regions with the least favourable colorectal-cancer mortality-to-incidence ratios, a pattern driven by advanced-stage presentation that is faithfully mirrored in our cohort, in which more than nine of every ten patients had Dukes C/D disease.[2,3] In such a population, physiological reserve is frequently eroded before the patient reaches the operating theatre, so the internist's pre-operative window, however brief, is the point of greatest leverage over modifiable risk. Anaemia correction, nutritional optimisation and cardiorespiratory assessment during that window are precisely the levers that our data identify as relevant to recovery, and they fall naturally within the scope of hospital internal medicine rather than of the operating surgeon alone.

Finally, our findings should be interpreted alongside the broader literature on postoperative recovery. The convergence of three independent signals in our data, the null for CR-POSSUM against stay, the strong anaemia effect, and the dominant contribution of in-hospital morbidity, is internally consistent and mirrors patterns reported in large registry and national cohort studies, lending external plausibility despite the modest sample.[4,8] We therefore regard the present study as a hypothesis-generating pilot that both justifies and specifies the design of a definitive

prospective, multicentre, patient-level investigation of length-of-stay determinants in the Indonesian colorectal-surgery population.

5. Conclusion

In colorectal-cancer surgery at Prof. Dr. I.G.N.G. Ngoerah General Hospital, the preoperative CR-POSSUM score did not predict prolonged postoperative length of stay (RR 1.12, 95% CI 0.59-2.12; AUC 0.42, 95% CI 0.26-0.57) but was a strong predictor of 30-day mortality (RR 6.72, 95% CI 0.87-52.05; AUC 0.93, 95% CI 0.79-1.00). Length of stay was instead determined by modifiable clinical factors, chiefly preoperative anaemia (adjusted OR 5.20, 95% CI 1.45-18.69) and in-hospital morbidity (RR 2.11, 95% CI 1.20-3.70; NNT 2.5). Indonesian internists should apply CR-POSSUM for mortality-risk communication rather than discharge planning, and prioritise preoperative anaemia correction and ERAS-aligned complication prevention to shorten stay. Larger, prospective, multicentre studies with complete patient-level data are warranted to confirm these findings and to develop locally calibrated length-of-stay prediction models.

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Author contributions (CRediT)

S.U.C.: conceptualization, methodology, formal analysis, investigation, writing — original draft. I.K.S.: supervision, validation, writing — review & editing. M.M.: supervision, resources, writing — review & editing. All authors approved the final version.

Ethics and consent

Prior to commencement, ethical approval and research permission were obtained from the Research and Development Unit (Litbang) of the Faculty of Medicine, Universitas Udayana / Prof. Dr. I.G.N.G. Ngoerah General Hospital, Denpasar. The study complied with the Declaration of Helsinki and with COPE and ICMJE standards. Because the design was a retrospective review of de-identified electronic medical records, the requirement for individual written informed consent was waived by the committee; all patient data were kept strictly confidential, anonymised, and used solely for research purposes. The authors declare no conflicts of interest and received no funding.

Conflict of interest

The authors declare no conflict of interest.

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Use of AI / Data availability

No generative-AI tools were used to create the scientific content, data or conclusions of this study. The de-identified aggregate data supporting the findings are available from the corresponding author on reasonable request, consistent with patient-privacy requirements.

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