



Impact of Preoperative Anaemia on Postoperative Outcomes Following Curative Surgery for Stage I–III Colorectal Cancer: A Retrospective Cohort Study

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Abstract

Background

Preoperative anaemia (POA) is frequently encountered in patients with colorectal cancer (CRC) and has been associated with adverse surgical outcomes. However, evidence regarding its impact on long-term postoperative complications in the Indian population is limited. This study evaluated the association between POA and postoperative morbidity, mortality, and long-term outcomes in patients undergoing curative surgery for Stage I–III CRC.

Materials and Methods

A retrospective cohort study was conducted on 150 patients with histopathologically confirmed Stage I–III CRC who underwent curative surgical resection at Government General Hospital, Rangaraya Medical College, Kakinada, India, between January 2017 and December 2019. Median follow-up was 54 months (ranging from 42–66 months). Patients were categorized as anaemic (n=76) or non-anaemic (n=74) according to preoperative haemoglobin levels. Anaemic patients were further classified as having mild-to-moderate (n=22) or severe anaemia (n=54). Postoperative mortality, tumour recurrence, small bowel obstruction, abdominal wall defects, and perioperative blood transfusion were compared using the Chi-square test or Fisher's exact test, with $P < 0.05$ considered statistically significant.

Results

POA was present in 76 (50.7%) patients. Baseline age and gender distributions were comparable between the anaemic and non-anaemic groups, although severe anaemia was more prevalent in males ($P = 0.016$). Compared with non-anaemic patients, anaemic patients had significantly higher rates of postoperative mortality (19.7% vs. 4.1%; $P = 0.003$), tumour recurrence (34.2% vs. 5.4%; $P < 0.0001$), small bowel obstruction (21.1% vs. 2.7%; $P = 0.0005$), abdominal wall defects (32.9% vs. 2.7%; $P < 0.0001$), and perioperative blood transfusion (77.6% vs. 5.4%; $P < 0.0001$). Within the anaemic group, severe anaemia was significantly associated with abdominal wall defects ($P = 0.022$) and blood

transfusion requirements ($P < 0.0001$), whereas differences in mortality, tumour recurrence, and small bowel obstruction were not statistically significant.

Conclusion

POA is associated with significantly poorer postoperative outcomes following curative surgery for Stage I–III CRC. Routine preoperative screening and optimisation of anaemia may reduce postoperative morbidity and transfusion requirements, supporting its incorporation into perioperative patient blood management strategies.

Keywords: Colorectal cancer, Preoperative Anaemia, Blood Transfusion, Postoperative Complications, Mortality, Recurrence.

Introduction

Colorectal cancer (CRC) is one of the most common malignancies worldwide and remains a major cause of cancer-related morbidity and mortality. According to the GLOBOCAN 2020 estimates, CRC is the third most frequently diagnosed cancer and the second leading cause of cancer-related deaths globally in 2020. Although historically more prevalent in developed countries, the incidence of CRC has increased substantially in low- and middle-income countries, including India, largely because of urbanization, westernized dietary habits, sedentary lifestyles, obesity, tobacco and alcohol consumption, and increasing life expectancy.[1][2]

Curative surgical resection remains the standard treatment for patients with localized Stage I–III CRC. Despite considerable advances in surgical techniques, perioperative anaesthesia, enhanced recovery after surgery protocols, and multidisciplinary oncological care, postoperative morbidity, disease recurrence, and mortality continue to pose significant clinical challenges.[2][3] Consequently, increasing attention has focused on identifying potentially modifiable preoperative risk factors that may influence surgical and oncological outcomes.

Preoperative anaemia (POA) is one of the most common comorbidities in patients with CRC, with a reported prevalence ranging from 30% to 80%.[4][5] Chronic occult gastrointestinal blood loss remains the principal cause, although anaemia is frequently multifactorial, resulting from iron deficiency, chronic inflammation, nutritional deficiencies, renal dysfunction, and impaired erythropoiesis associated with malignancy.[6][7] Reduced haemoglobin levels compromise tissue oxygenation, impair collagen synthesis, angiogenesis, immune function, and wound healing, thereby increasing the risk of postoperative complications and delayed recovery.[8] Furthermore, severe anaemia often necessitates perioperative blood transfusion, which has been associated with increased postoperative morbidity and adverse oncological outcomes.[9][10]

Beyond its influence on short-term surgical outcomes, POA may also adversely affect long-term outcomes. Tumour hypoxia promotes activation of hypoxia-inducible pathways, enhancing angiogenesis, tumour progression, metastatic potential, and resistance to anticancer therapy.[8][11] Consequently, anaemia has been proposed as an important prognostic marker in patients undergoing CRC surgery. These observations have led to the adoption of Patient Blood Management (PBM) strategies that emphasize early identification and correction of anaemia before major surgery to reduce transfusion requirements and improve perioperative outcomes. [10][11]

Although substantial international evidence supports the prognostic significance of POA, data from the Indian population remain limited, particularly regarding its association with long-term postoperative complications. Therefore, the present retrospective study was undertaken to evaluate the impact of POA on postoperative mortality, tumour recurrence, small bowel obstruction, abdominal wall defects, and perioperative blood transfusion in patients undergoing curative surgery for Stage I–III CRC.

Materials and Methods

Study Design and Study Population

This retrospective cohort study was conducted in the Department of General Surgery, Government General Hospital, Rangaraya Medical College, Kakinada, Andhra Pradesh, India, a tertiary-care teaching hospital. The study included consecutive patients with histopathologically confirmed Stage I–III colorectal adenocarcinoma who underwent curative-intent surgical resection between January 2017 and December 2019. Institutional Ethics Committee approval was obtained before commencement of the study.

Among 196 patients who underwent surgery during the study period, 150 fulfilled the eligibility criteria and had complete clinical records and follow-up data for inclusion in the final analysis. Adult patients (≥ 18 years) with Stage I–III CRC undergoing curative resection and documented preoperative haemoglobin levels were included. Patients with Stage IV disease, unresectable tumours, benign colorectal disorders, incomplete medical records, or loss to follow-up were excluded. Consecutive sampling was employed to minimize selection bias.

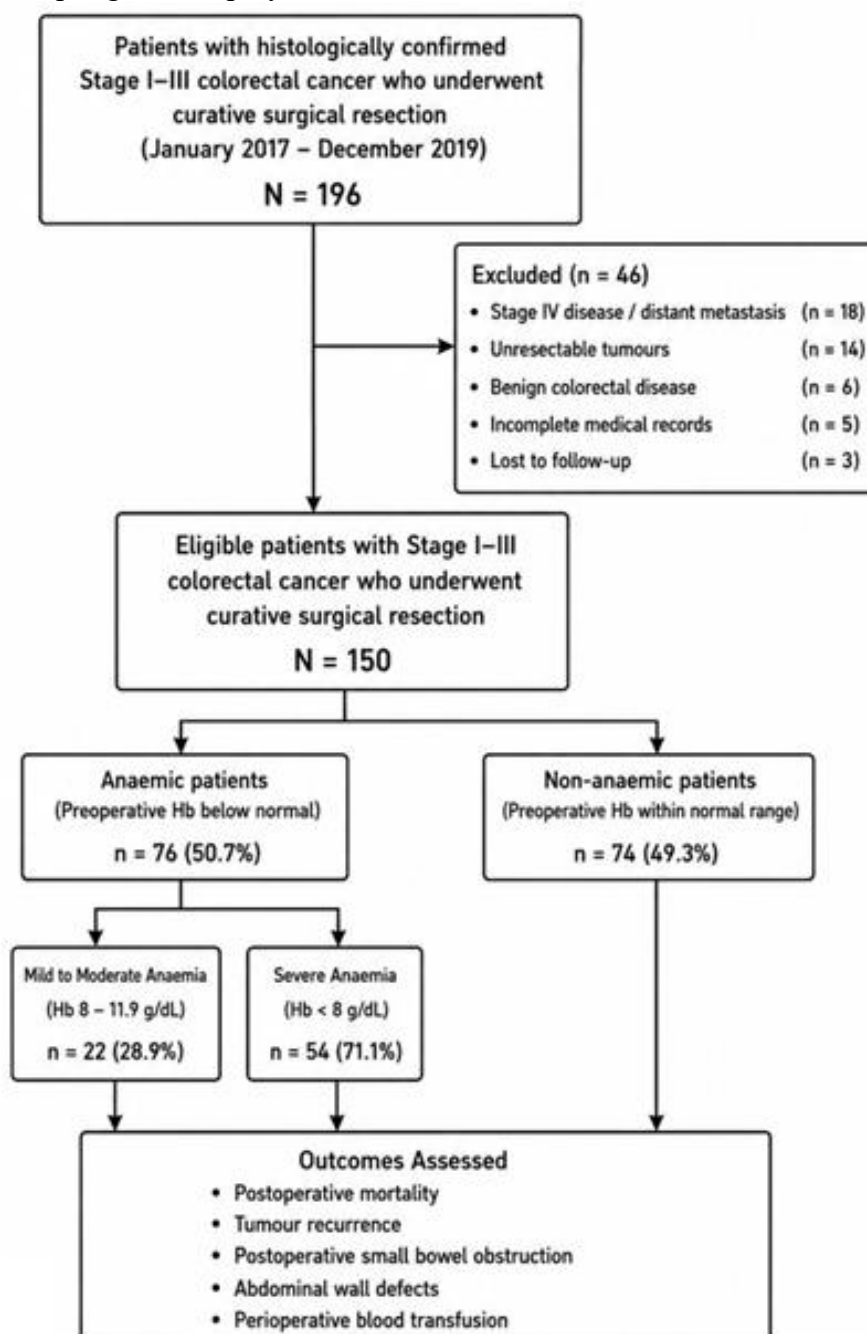


Figure 1: Flow diagram of patient selection and study design

Data Collection and Study Variables

Clinical information was retrieved from hospital records, operative notes, pathology reports, and follow-up records using a standardized data collection proforma. Variables collected included age, gender, preoperative haemoglobin concentration, perioperative blood transfusion, postoperative mortality, tumour recurrence, postoperative small bowel obstruction, and abdominal wall defects.

Institutional perioperative anaemia management protocol

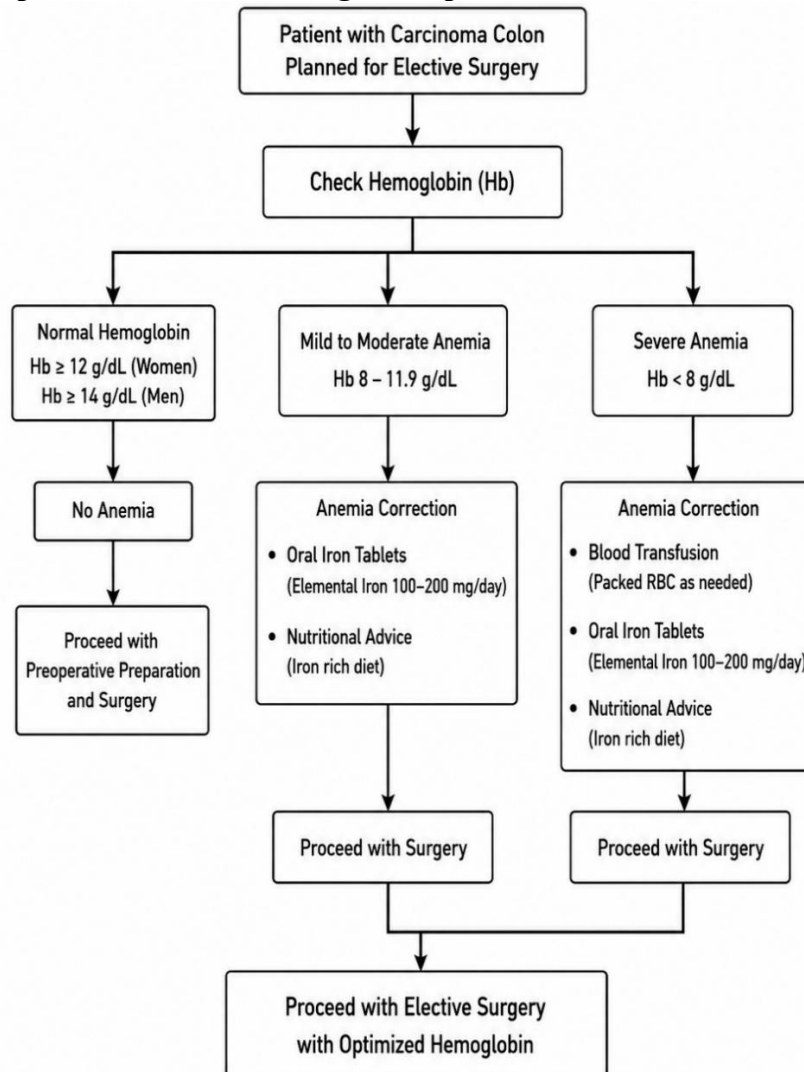


Figure 2: Institutional perioperative anaemia management protocol

Anaemia Definition

Anaemia was defined according to the World Health Organization criteria. Mild and moderate anaemia were combined because of limited sample size.

Anaemia status of the patients	Haemoglobin values
Within normal limits	12.0-16.0 g/dl for women 14.0-18.0 g/dl for men
Mild	10.0 to levels within normal limits
Moderate	8.0-10.0 g/dl
Severe	< 8 g/dl

Table 1: Anaemia status of the patient

Patients were categorized according to preoperative haemoglobin levels into anaemic (n=76) and non-anaemic (n=74) groups. The anaemic cohort was further classified as mild-to-moderate anaemia (n=22) or severe anaemia (n=54), with severe anaemia defined as a haemoglobin concentration <8 g/dL.

Median follow-up was 54 months (ranging from 42-66 months)

Outcome Measures

The primary outcome was postoperative mortality. Secondary outcomes included tumour recurrence, postoperative small bowel obstruction, abdominal wall defects, and the requirement for perioperative blood transfusion. Follow-up information was obtained from outpatient records and hospital readmissions to identify postoperative complications and oncological outcomes.

Perioperative anaemia management reflected routine institutional practice. Patients received blood transfusions and iron supplementation when clinically indicated, at the treating surgeon's discretion; therefore, treatment protocols were not standardized because of the retrospective study design.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics software (version 25.0) (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages. Comparisons between groups were performed using appropriate statistical tests like Pearson's Chi-square test or Fisher's exact test. A two-sided P value <0.05 was considered statistically significant.

Results

Baseline characteristics

Table 2: Baseline characteristics of the study population

Study variable		Total study population (n=150)	Status of the patient		chi-square	p-value
			Anaemic (n=76)	Non-anaemic (n=74)		
Age (years)	≤ 60	34	16	18	0.229	0.632
	> 60	116	60	56		
Gender	Male	88	47	41	0.640	0.423
	Female	62	29	33		

The study included 150 patients who underwent curative surgery for Stage I–III CRC. POA was identified in 76 patients (50.7%), whereas 74 patients (49.3%) had normal haemoglobin levels. The majority of patients (77.3%) were older than 60 years. The age distribution was comparable between anaemic and non-anaemic patients (78.9% vs. 75.7%; $\chi^2 = 0.229$, $P = 0.632$). Similarly, gender distribution did not differ significantly between the two groups ($\chi^2 = 0.640$, $P = 0.423$). (as shown in Table 2)

Table 3: Baseline characteristics of the Anaemic patients

Study variable		Total study population (n=76)	Anaemic patients		chi-square	p-value
			Mild-Moderate (n=22)	Severe (n=54)		
Age (years)	≤ 60	17	4	13	0.312	0.576
	> 60	59	18	41		
Gender	Male	47	9	38	5.749	0.016
	Female	29	13	16		

Among the anaemic group, severe anaemia was more prevalent than mild-to-moderate anaemia (71.1% vs. 28.9%). Although the age distribution was similar across severity groups ($P = 0.576$),

severe anaemia was significantly more prevalent among male patients ($\chi^2 = 5.749$, $P = 0.016$). (as shown in Table 3)

Association between anaemia and postoperative outcomes

Table 4: Study outcomes of the study population

Study Outcomes		Total study population (n=150)	Status of the patients		p-value
			Anaemic (n=76)	Non-anaemic (n=74)	
Mortality	Yes	18	15	3	0.0046*
	No	132	61	71	
Tumour recurrence	Yes	30	26	4	< 0.0001*
	No	120	50	70	
Small bowel obstruction	Yes	18	16	2	0.0007*
	No	132	60	72	
Abdominal wall defects	Yes	27	25	2	< 0.0001*
	No	123	51	72	
Blood transfusion done	Yes	63	59	4	< 0.0001*
	No	87	17	70	

* Fisher's exact test

Overall postoperative mortality was observed in 18 patients (12.0%). Mortality occurred significantly more frequently among anaemic patients than non-anaemic patients (19.7% vs. 4.1%, Odds ratio = 5.82, $P = 0.0046$). Tumour recurrence developed in 30 patients (20.0%). The recurrence rate was substantially higher in the anaemic group than in the non-anaemic group (34.2% vs. 5.4%; Odds ratio = 9.10, $P < 0.0001$).

Postoperative small bowel obstruction occurred in 18 patients (12.0%). Anaemic patients had a significantly greater prevalence than non-anaemic patients (21.1% vs. 2.7%; Odds ratio = 9.60, $P = 0.0007$). Abdominal wall defects were documented in 27 patients (18.0%). The prevalence was significantly higher among anaemic patients than among non-anaemic patients (32.9% vs. 2.7%; Odds ratio = 17.65, $P < 0.0001$). Perioperative blood transfusion was administered to 63 patients (42.0%). Blood transfusion was required in 77.6% of anaemic patients compared with only 5.4% of non-anaemic patients, demonstrating a highly significant association with POA (Odds ratio = 60.74, $P < 0.0001$). (as shown in Table 4)

Outcomes according to severity of anaemia

Table 5: Study outcomes of the Anaemic patients

Study Outcomes		Total study population (n=76)	Anaemic patients		p-value
			Mild-Moderate (n=22)	Severe (n=54)	
Mortality	Yes	15	3	12	0.532*
	No	61	19	42	
Tumour recurrence	Yes	26	8	18	0.801**
	No	50	14	36	
Small bowel obstruction	Yes	16	2	14	0.129*
	No	60	20	40	
Abdominal wall defects	Yes	25	3	22	0.031*
	No	51	19	32	

Blood transfusion done	Yes	59	5	54	< 0.0001*
	No	17	17	0	

* Fisher's exact test, ** Chi-square test

Although mortality rate was higher in patients with severe anaemia than in those with mild-to-moderate anaemia (22.2% vs. 13.6%), the difference was not statistically significant (Odds ratio = 0.553, $P = 0.532$). Similarly, Tumour recurrence rates were comparable between the groups (36.4% vs 33.3%, $\chi^2 = 0.063$, $P = 0.801$). Postoperative small bowel obstruction was observed in 25.9% of patients with severe anaemia compared with 9.1% of patients with mild-to-moderate anaemia, with no statistically significant difference. (Odds ratio = 0.286, $P = 0.129$).

Abdominal wall defects were present in 40.7% of patients with severe anaemia, compared with 13.6% of those with mild-to-moderate anaemia. This difference was statistically significant (Odds ratio = 0.230, $P = 0.031$). Perioperative blood transfusion was administered to all patients with severe anaemia (54/54, 100%), whereas only 5 patients (22.7%) with mild-to-moderate anaemia required transfusion. The requirement for blood transfusion was significantly higher among patients with severe anaemia ($P < 0.0001$). (as shown in Table 5)

Multivariable Logistic Regression

Table 6: Multivariable regression analysis of factors associated with postoperative outcomes

Outcome	Adjusted OR for preoperative anaemia (95% CI)	P value
Mortality	6.00 (1.64–21.92)	0.0067
Tumour recurrence	9.10 (2.97–27.87)	<0.001
Small bowel obstruction	9.65 (2.11–44.06)	0.0035
Abdominal wall defects	20.94 (4.61–95.13)	<0.001
Blood transfusion	75.02 (22.04–255.40)	<0.001

Multivariable logistic regression analysis was performed after adjusting for age and gender. POA remained an independent predictor of adverse postoperative outcomes. Patients with POA had significantly higher odds of postoperative mortality (adjusted OR 6.00, 95% CI 1.64–21.92; $P = 0.0067$), tumour recurrence (adjusted OR 9.10, 95% CI 2.97–27.87; $P < 0.001$), small bowel obstruction (adjusted OR 9.65, 95% CI 2.11–44.06; $P = 0.0035$), abdominal wall defects (adjusted OR 20.94, 95% CI 4.61–95.13; $P < 0.001$), and perioperative blood transfusion (adjusted OR 75.02, 95% CI 22.04–255.40; $P < 0.001$). Age and gender were not independently associated with any of the postoperative outcomes. (as shown in Table 6)

Discussion

The present study evaluated the association between POA and postoperative outcomes in patients undergoing curative surgery for Stage I–III CRC. Approximately 50% of the study population (50.7%) was anaemic at the time of surgery, highlighting the high prevalence of anaemia among CRC patients. The principal finding was that patients with POA experienced significantly higher rates of postoperative mortality, tumour recurrence, small bowel obstruction, abdominal wall defects, and perioperative blood transfusion than non-anaemic patients. However, when anaemic patients were stratified according to severity, severe anaemia was significantly associated only with abdominal wall defects and the requirement for blood transfusion. In contrast, differences in mortality, tumour recurrence, and small bowel obstruction were not statistically significant.

Anaemia is one of the commonest systemic manifestations of CRC and is primarily attributed to chronic occult gastrointestinal blood loss, iron deficiency, cancer-related inflammation, nutritional deficiencies, and impaired erythropoiesis. Ludwig H et al. [4] and Knight K et al. [5] reported that approximately 30–80% of CRC patients are anaemic at presentation, findings comparable to those

observed in the present study. Weiss G et al. [6] and Ganz T et al. [7] further reported that inflammatory cytokines, particularly interleukin-6, stimulate hepcidin production, thereby impairing iron metabolism and contributing to cancer-associated anaemia.

A major observation in the present study was the significantly higher postoperative mortality among anaemic patients. This finding is consistent with the study by Musallam KM et al. [9], who reported that anaemia was associated with increased postoperative mortality and major complications following non-cardiac surgery. Similarly, Baron DM et al. [10] reported poorer postoperative outcomes among anaemic surgical patients, while the meta-analysis by Fowler AJ et al. [12] confirmed POA as a predictor of postoperative mortality across multiple surgical specialties. The adverse effect of anaemia is biologically plausible because reduced haemoglobin concentration compromises oxygen delivery to healing tissues and vital organs, resulting in impaired wound healing, reduced immune function, and increased susceptibility to postoperative complications. [6][8] Although mortality was higher among patients with severe anaemia than those with mild-to-moderate anaemia, the difference did not reach statistical significance. This finding is likely attributable to the relatively small sample size of the subgroup analysis and limited statistical power rather than the absence of a biological relationship. Similar observations have been reported in retrospective cohort studies, where inadequate subgroup size limited the ability to demonstrate statistically significant differences despite clinically meaningful trends. [12]

Tumour recurrence was significantly more frequent among anaemic patients than among non-anaemic patients. Richards CH et al. [13] reported that systemic inflammation and impaired physiological reserve adversely influence long-term survival following curative CRC surgery. Likewise, anaemia as an adverse prognostic factor across several malignancies. Chronic tissue hypoxia resulting from reduced haemoglobin concentration activates hypoxia-inducible factors, promoting angiogenesis, tumour proliferation, invasion, and metastatic potential, as described by Rankin EB and Giaccia AJ. [14] Persistent systemic inflammation and impaired host immunity may further contribute to tumour progression. However, within the anaemic cohort, tumour recurrence did not differ significantly between patients with mild-to-moderate and severe anaemia, suggesting that the presence of anaemia itself may be more clinically relevant than the degree of haemoglobin reduction.

The prevalence of postoperative small bowel obstruction was significantly higher among anaemic patients than among non-anaemic patients. Adhesive intestinal obstruction remains a recognised long-term complication of colorectal surgery. Parker MC et al. [15] and Ten Broek RPG et al. [16] reported that postoperative adhesions are responsible for a substantial proportion of intestinal obstruction following abdominal surgery. Tissue hypoxia associated with anaemia may impair peritoneal healing, prolong inflammation, and increase adhesion formation. Nevertheless, although patients with severe anaemia experienced a higher frequency of postoperative bowel obstruction, the difference did not reach statistical significance, again possibly reflecting limited statistical power.

Abdominal wall defects represented the only postoperative complication that showed a statistically significant association with the severity of anaemia. Patients with severe anaemia had a markedly greater prevalence of abdominal wall defects than those with mild-to-moderate anaemia. This observation is biologically plausible because adequate tissue oxygenation is essential for collagen synthesis, angiogenesis, fibroblast proliferation, and fascial healing. Franz MG [17] described the central role of collagen remodelling in abdominal wall repair, whereas Sørensen LT [18] highlighted the importance of tissue oxygenation in successful wound healing. Severe anaemia may therefore impair fascial integrity and predispose patients to incisional hernia or other abdominal wall complications following colorectal surgery.

Perioperative blood transfusion was strongly associated with POA. More than 75% of anaemic patients required transfusion, whereas only a small proportion of non-anaemic patients received blood products. Furthermore, every patient with severe anaemia required perioperative transfusion. Similar findings have been reported by Leichtle SW et al. [19] and Nilsson KR et al. [20], who identified POA as one of the strongest predictors of perioperative transfusion in colorectal surgery. Although

blood transfusion remains essential in selected patients, Amato A and Pescatori M [21] and Acheson AG et al. [22] suggested that perioperative allogeneic transfusion may be associated with increased postoperative morbidity and poorer oncological outcomes. Consequently, avoidance of unnecessary transfusion remains an important goal of perioperative management.

The findings of the present study support the principles of PBM. Muñoz M et al. [11] and Meybohm P et al. [23] recommended routine screening and correction of POA before major elective surgery. International consensus guidelines advocate early identification of iron deficiency, optimisation of haemoglobin concentration, and restrictive transfusion strategies to improve perioperative outcomes. The IVICA trial by Keeler BD et al. [24] reported that intravenous iron effectively improved preoperative haemoglobin levels in patients with CRC, supporting the implementation of evidence-based anaemia optimisation programmes.

Conclusion

POA was present in approximately 50% of the patients undergoing curative surgery for Stage I–III CRC and was associated with significantly higher postoperative mortality, tumour recurrence, small bowel obstruction, abdominal wall defects, and perioperative blood transfusion compared with patients without anaemia. Within the anaemic cohort, severe anaemia was significantly associated with abdominal wall defects and a greater requirement for blood transfusion, whereas differences in mortality, tumour recurrence, and small bowel obstruction did not reach statistical significance.

These findings support routine assessment and optimisation of anaemia before surgery to improve postoperative outcomes in patients undergoing surgery.

Strengths

The present study included a relatively homogeneous group of patients with Stage I–III CRC who underwent curative-intent surgery at a single tertiary-care centre using uniform institutional management protocols. The study evaluated both short-term and long-term clinically relevant outcomes and incorporated multivariable analysis to adjust for potential confounding by age and gender.

Limitations

Its retrospective, single-centre design may limit the generalizability of the findings and is subject to inherent selection bias. The sample size was relatively small, particularly for subgroup analyses of anaemia severity, which may have reduced the statistical power to detect differences. In addition, adjustment for potential confounders was limited by the availability of retrospective data, and factors such as tumour stage, comorbidities, nutritional status, and adjuvant therapy could not be fully evaluated.

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