ORIGINAL ARTICLE

The Effect of Preoperative Anemia on the Odds of Allogeneic Blood Transfusion and Patient Outcomes in Colorectal Neoplasm Patients

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SUMMARY

Background: The optimal preoperative hemoglobin (Hb) value of colorectal neoplasm patients is still being debated. This study aimed at determining the effect of preoperative anemia on patient outcomes and allogeneic blood transfusion (ABT).
Methods: This retrospective cohort study enrolled colorectal neoplasm patients, that underwent surgery, from January 1, 2012, to December 31, 2021. The primary outcomes were the association between anemia and average length of stay (ALOS) and the odds of ABT. The secondary outcomes were the risk factors of the primary outcomes. Univariate and multivariate logistic regression analyses were applied to identify the association and risk factors.
Results: A total of 14,352 inpatients were included in the study, of whom 3,035 experienced (21.15%) mild anemia, 1,500 (10.45%) moderate anemia, and 104 (0.72%) severe anemia. Overall, 1,418 (9.88%) patients received ABT during the hospitalization, and 546 (3.80%) patients received perioperative ABT. In the multivariate logistic regression analysis, compared with the no anemic group, the odds ratio [OR] of ABT during the hospitalization for patients with mild/moderate/severe anemia were 5.915, 95% confidence interval [CI]: 4.717 - 7.418; 104.777, 95% CI: 84.345 - 130.160; and 13,361.442, 95% CI: 816.004 - 218,783.511, respectively, and the OR of perioperative ABT were 4.332, 95% CI: 3.245 - 5.785; 27.492, 95% CI: 20.974 - 36.037; and 20.912, 95% CI: 11.832 - 36.959, respectively. Besides, the ALOS was longer, β were 0.619, 95% CI: 0.346 - 0.892; 1.188, 95% CI: 0.821 - 1.554; and 1.395, 95% CI: 0.107 - 2.684, respectively.
Conclusions: Anemia is a common phenomenon in colorectal neoplasm surgical patients, and even mild anemia could be a deleterious predictor on the outcomes of colorectal neoplasm patients that underwent surgery.
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Supplementary Data

Table S1. Baseline characteristics of colorectal neoplasm patients.

		Normal	Mild anemia	Moderate anemia	Severe anemia	χ^2	p
		(n = 9,713)	(n = 3,035)	(n = 1,500)	(n = 104)		
Demographic variables							
Age, years							
< 60	6,263 (43.64)	4,486 (71.63)	1,138 (18.17)	596 (9.52)	43 (0.69)		
60 - 69	4,480 (31.22)	3,112 (69.46)	925 (20.65)	413 (9.22)	30 (0.67)	191.662	< 0.001
≥ 70	3,609 (25.15)	2,115 (58.60)	972 (26.93)	491 (13.60)	31 (0.86)		
Gender							
Female	5,982 (41.68)	3,828 (63.99)	1,323 (22.12)	791 (13.22)	40 (0.67)	100.968	< 0.001
Male	8,370 (58.32)	5,885 (70.31)	1,712 (20.45)	709 (8.47)	64 (0.76)		
BMI							
Thin	1,193 (8.31)	662 (55.49)	324 (27.16)	196 (16.43)	11 (0.92)		
Normal	7,891 (54.98)	5,134 (65.06)	1,794 (22.73)	897 (11.37)	66 (0.84)	227.950	< 0.001
Overweight	4,327 (30.15)	3,197 (73.88)	762 (17.61)	342 (7.90)	26 (0.60)		
Obese	941 (6.56)	720 (76.51)	155 (16.47)	65 (6.91)	1 (0.11)		
Smoking							
No	10,608 (73.91)	7,059 (66.54)	2,262 (21.32)	1,210 (11.41)	77 (0.73)	43.795	< 0.001
Yes	3,744 (26.09)	2,654 (70.89)	773 (20.65)	290 (7.75)	27 (0.72)		
Previous history							
Surgery history							
No	9,046 (63.03)	6,248 (69.07)	1,827 (20.20)	903 (9.98)	68 (0.75)	22.854	< 0.001
Yes	5,306 (36.97)	3,465 (65.30)	1,208 (22.77)	597 (11.25)	36 (0.68)		
Transfusion history							
No	13,864 (96.60)	9,503 (68.54)	2,923 (21.08)	1,349 (9.73)	89 (0.64)	287.537	< 0.001
Yes	488 (3.40)	210 (43.03)	112 (22.95)	151 (30.94)	15 (3.07)		
Comorbidity							
Hypertension							
No	11,398 (79.42)	7,809 (68.51)	2,331 (20.45)	1,171 (10.27)	87 (0.76)	21.204	< 0.001
Yes	2,954 (20.58)	1,904 (64.45)	704 (23.83)	329 (11.14)	17 (0.58)		
Diabetes							
No	12,908 (89.94)	8,833 (68.43)	2,684 (20.79)	1,297 (10.05)	94 (0.73)	38.351	< 0.001
Yes	1,444 (10.06)	880 (60.94)	351 (24.31)	203 (14.06)	10 (0.69)		

Table S1. Baseline characteristics of colorectal neoplasm patients (continued).

		Normal	Mild anemia	Moderate anemia	Severe anemia	χ2	p
		(n = 9,713)	(n = 3,035)	(n = 1,500)	(n = 104)		
Pulmonary infection							
No	13,206 (92.02)	9,029 (68.37)	2,739 (20.74)	1,346 (10.19)	92 (0.70)	37.079	< 0.001
Yes	1,146 (7.98)	684 (59.69)	296 (25.83)	154 (13.44)	12 (1.05)		
Hyperlipidemia							
No	14,335 (99.88)	9,701 (67.67)	3,032 (21.15)	1,498 (10.45)	104 (0.73)	/	0.940
Yes	17 (0.12)	12 (70.59)	3 (17.65)	2 (11.76)	0 (0.00)		
Coronary heart disease							
No	13,206 (92.02)	9,029 (68.37)	2,739 (20.74)	1,346 (10.19)	92 (0.70)	37.079	< 0.001
Yes	1,146 (7.98)	684 (59.69)	296 (25.83)	154 (13.44)	12 (1.05)		
Tumor location							
Right half colon							
No	11,868 (82.69)	8,819 (74.31)	2,257 (19.02)	746 (6.29)	46 (0.39)	1,838.675	< 0.001
Yes	2,484 (17.31)	894 (35.99)	778 (31.32)	754 (30.35)	58 (2.33)		
Transverse colon							
No	11,285 (78.63)	8,423 (74.64)	2,116 (18.75)	707 (6.26)	39 (0.35)	1,511.893	< 0.001
Yes	3,067 (21.37)	1,290 (42.06)	919 (29.96)	793 (25.86)	65 (2.12)		
Left half colon							
No	13,229 (92.18)	9,013 (68.13)	2,775 (20.98)	1,343 (10.15)	98 (0.74)	22.584	< 0.001
Yes	1,123 (7.82)	700 (62.33)	260 (23.15)	157 (13.98)	6 (0.53)		
Sigmoid colon							
No	10,965 (76.40)	7,299 (66.57)	2,338 (21.32)	1,234 (11.25)	94 (0.86)	49.054	< 0.001
Yes	3,387 (23.60)	2,414 (71.27)	697 (20.58)	266 (7.85)	10 (0.30)		
Rectum							
No	4,678 (32.59)	2,238 (47.84)	1,324 (28.30)	1,038 (22.19)	78 (1.67)	1,571.483	< 0.001
Yes	9,674 (67.41)	7,475 (77.27)	1,711 (17.69)	462 (4.78)	26 (0.27)		
Operation method							
Non-laparoscopy	7,575 (52.78)	4,723 (62.35)	1,726 (22.79)	1,048 (13.83)	78 (1.03)	283.952	< 0.001

BMI - body mass index, continuous variables shown as mean (SD), categorical variables shown as number (percentage)/means Fisher's exact test without statistic.

Table S2. Univariate analysis of the baseline characteristics and ABT.

Variables	Total	ABT during the hospitalization				Perioperative ABT			
		no (n = 12,934)	yes (n = 1,418)	χ^2	p	no (n = 13,806)	yes (n = 546)	χ^2	p
Demographic variables									
Age, years									
< 60	6,263 (43.64)	5,740 (91.65)	523 (8.35)	111.035	< 0.001	6,065 (96.84)	198 (3.16)	47.741	< 0.001
60 - 69	4,480 (31.22)	4,105 (91.63)	375 (8.37)			4,338 (96.83)	142 (3.17)		
≥ 70	3,609 (25.15)	3,089 (85.59)	520 (14.41)			3,403 (94.29)	206 (5.71)		
Gender									
Female	5,982 (41.68)	5,270 (88.10)	712 (11.90)	47.109	< 0.001	5,710 (95.45)	272 (4.55)	15.457	< 0.001
Male	8,370 (58.32)	7,664 (91.57)	706 (8.43)			8,096 (96.73)	274 (3.27)		
BMI									
Thin	1,193 (8.31)	1,006 (84.33)	187 (15.67)	72.617	< 0.001	1,126 (94.38)	67 (5.62)	13.568	< 0.001
Normal	7,891 (54.98)	7,076 (89.67)	815 (10.33)			7,594 (96.24)	297 (3.76)		
Overweight	4,327 (30.15)	3,972 (91.80)	355 (8.20)			4,172 (96.42)	155 (3.58)		
Obese	941 (6.56)	880 (93.52)	61 (6.48)			914 (97.13)	27 (2.87)		
Smoking									
No	10,608 (73.91)	9,477 (89.34)	1,131 (10.66)	27.900	< 0.001	10,159 (95.77)	449 (4.23)	20.384	< 0.001
Yes	3,744 (26.09)	3,457 (92.33)	287 (7.67)			3,647 (97.41)	97 (2.59)		
Anemia									
Normal	9,713 (67.68)	9,595 (98.79)	118 (1.21)	6,554.756	< 0.001	9,631 (99.16)	82 (0.84)	1,602.114	< 0.001
Mild anemia	3,035 (21.15)	2,786 (91.80)	249 (8.20)			2,915 (96.05)	120 (3.95)		
Moderate anemia	1,500 (10.45)	553 (36.87)	947 (63.13)			1,174 (78.27)	326 (21.73)		
Severe anemia	104 (0.72)	0 (0.00)	104 (100.00)			86 (82.69)	18 (17.31)		
Previous history									
Surgery history									
No	9,046 (63.03)	8,205 (90.70)	841 (9.30)	9.348	< 0.001	8,722 (96.42)	324 (3.58)	3.315	0.069
Yes	5,306 (36.97)	4,729 (89.13)	577 (10.87)			5,084 (95.82)	222 (4.18)		
Transfusion history									
No	13,864 (96.60)	12,581 (90.75)	1,283 (9.25)	179.435	< 0.001	13,368 (96.42)	496 (3.58)	57.278	< 0.001
Yes	488 (3.40)	353 (72.34)	135 (27.66)			438 (89.75)	50 (10.25)		

Table S2. Univariate analysis of the baseline characteristics and ABT (continued).

Variables	Total	ABT during the hospitalization				Perioperative ABT			
		no (n = 12,934)	yes (n = 1,418)	χ2	p	no (n = 13,806)	yes (n = 546)	χ2	p
Comorbidity									
Hypertension									
No	11,398 (79.42)	10,330 (90.63)	1,068 (9.37)	16.182	< 0.001	10,998 (96.49)	400 (3.51)	13.165	< 0.001
Yes	2,954 (20.58)	2,604 (88.15)	350 (11.85)			2,808 (95.06)	146 (4.94)		
Diabetes									
No	12,908 (89.94)	11,690 (90.56)	1,218 (9.44)	28.423	< 0.001	12,439 (96.37)	469 (3.63)	10.244	< 0.001
Yes	1,444 (10.06)	1,244 (86.15)	200 (13.85)			1,367 (94.67)	77 (5.33)		
Pulmonary infection									
No	13,206 (92.02)	11,975 (90.68)	1,231 (9.32)	57.966	< 0.001	12,756 (96.59)	450 (3.41)	71.157	< 0.001
Yes	1,146 (7.98)	959 (83.68)	187 (16.32)			1,050 (91.62)	96 (8.38)		
Hyperlipidemia									
No	14,335 (99.88)	12,919 (90.12)	1,416 (9.88)	< 0.001	0.999	13,790 (96.20)	545 (3.80)	/	0.483
Yes	17 (0.12)	15 (88.24)	2 (11.76)			16 (94.12)	1 (5.88)		
Coronary heart disease									
No	13,206 (92.02)	11,975 (90.68)	1,231 (9.32)	57.966	< 0.001	12,756 (96.59)	450 (3.41)	71.157	< 0.001
Yes	1,146 (7.98)	959 (83.68)	187 (16.32)			1,050 (91.62)	96 (8.38)		
Tumor location									
Right half colon									
No	11,868 (82.69)	11,148 (93.93)	720 (6.07)	1,119.912	< 0.001	11,569 (97.48)	299 (2.52)	309.377	< 0.001
Yes	2,484 (17.31)	1,786 (71.90)	698 (28.10)			2,237 (90.06)	247 (9.94)		
Transverse colon									
No	11,285 (78.63)	10,591 (93.85)	694 (6.15)	825.328	< 0.001	10,995 (97.43)	290 (2.57)	219.934	< 0.001
Yes	3,067 (21.37)	2,343 (76.39)	724 (23.61)			2,811 (91.65)	256 (8.35)		
Left half colon									
No	13,229 (92.18)	11,955 (90.37)	1,274 (9.63)	11.848	< 0.001	12,735 (96.27)	494 (3.73)	2.272	0.132
Yes	1,123 (7.82)	979 (87.18)	144 (12.82)			1,071 (95.37)	52 (4.63)		
Sigmoid colon									
No	10,965 (76.40)	9,808 (89.45)	1,157 (10.55)	23.537	< 0.001	10,526 (96.00)	439 (4.00)	5.043	0.025
Yes	3,387 (23.60)	3,126 (92.29)	261 (7.71)			3,280 (96.84)	107 (3.16)		

Table S2. Univariate analysis of the baseline characteristics and ABT (continued).

Variables	Total	ABT during the hospitalization				Perioperative ABT			
		no (n = 12,934)	yes (n = 1,418)	χ2	p	no (n = 13,806)	yes (n = 546)	χ2	p
Rectum									
No	4,678 (32.59)	3,727 (79.67)	951 (20.33)	851.012	< 0.001	4,360 (93.20)	318 (6.80)	169.930	< 0.001
Yes	9,674 (67.41)	9,207 (95.17)	467 (4.83)			9,446 (97.64)	228 (2.36)		
Operation method									
Non-laparoscopy	7,575 (52.78)	6,567 (86.69)	1,008 (13.31)	211.565	< 0.001	7,189 (94.90)	386 (5.10)	73.100	< 0.001
Laparoscopy	6,777 (47.22)	6,367 (93.95)	410 (6.05)			6,617 (97.64)	160 (2.36)		

BMI - body mass index, ABT - allogeneic blood transfusion, variables shown as number (percentage)/means Fisher's exact test without statistic.

Table S3. Univariate analysis of the baseline characteristics and ALOS.

Variables	ALOS		
	Days	t/F	p
Demographic variables			
Age, years			
< 60	13.28 ± 7.09	47.314	< 0.001
60 - 69	13.49 ± 5.43		
≥ 70	14.61 ± 7.53		
Gender			
Male	13.58 ± 7.72	-1.428	0.153
Female	13.75 ± 5.97		
BMI			
Thin	13.82 ± 5.9	0.307	0.820
Normal	13.66 ± 6.95		
Overweight	13.71 ± 6.79		
Obese	13.56 ± 5.96		
Smoking			
No	13.37 ± 7.02	-10.264	< 0.001
Yes	14.58 ± 5.87		
Anemia			
Normal	13.36 ± 6.46	25.964	< 0.001
Mild anemia	14.17 ± 6.35		
Moderate anemia	14.72 ± 9		
Severe anemia	14.96 ± 5.77		
Previous history			
Surgery history			
No	13.32 ± 7.16	-8.751	< 0.001
Yes	14.3 ± 5.96		

Table S3. Univariate analysis of the baseline characteristics and ALOS (continued).

Variables	ALOS		
	Days	***t*/F**	**p**
Transfusion history			
No	13.64 ± 6.77	**-4.942**	**< 0.001**
Yes	15.03 ± 6.1		
Comorbidity			
Hypertension			
No	13.48 ± 6.03	**-5.568**	**< 0.001**
Yes	14.45 ± 8.98		
Diabetes			
No	13.6 ± 6.79	**-4.411**	**< 0.001**
Yes	14.4 ± 6.45		
Pulmonary infection			
No	13.49 ± 6.44	**-8.313**	**< 0.001**
Yes	15.85 ± 9.41		
Hyperlipidemia			
No	13.68 ± 6.76	**-0.589**	**0.556**
Yes	14.65 ± 6.27		
Coronary heart disease			
No	13.49 ± 6.44	**-8.313**	**< 0.001**
Yes	15.85 ± 9.41		
Surgical site			
Right half colon			
No	13.58 ± 6.8	**-4.027**	**< 0.001**
Yes	14.17 ± 6.54		
Transverse colon			
No	13.68 ± 6.91	**-0.130**	**0.897**
Yes	13.7 ± 6.18		
Left half colon			
No	13.71 ± 6.86	**1.740**	**0.082**
Yes	13.41 ± 5.34		
Sigmoid colon			
No	13.69 ± 6.34	**0.140**	**0.889**
Yes	13.67 ± 7.95		
Rectum			
No	13.73 ± 6.12	**0.553**	**0.580**
Yes	13.66 ± 7.05		
Operation method			
Non-laparoscopy	13.72 ± 7.75	**0.795**	**0.427**
Laparoscopy	13.64 ± 5.43		

BMI - body mass index, ALOS - average length of stay, variables shown as mean ± SD.