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Impact of Preoperative Anemia on Outcomes in Adults Undergoing Elective Posterior Cervical Fusion

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Abstract

Study Design: Retrospective analysis of prospectively collected data.

Objectives: Few studies have investigated the role of preoperative anemia on postoperative outcomes of posterior cervical fusion. This study looked to investigate the potential relationship between preoperative anemia and postoperative outcomes following posterior cervical spine fusion.

Methods: Data from patients undergoing elective posterior cervical fusions between 2005 and 2012 was collected from the American College of Surgeons National Surgical Quality Improvement Program database using inclusion/exclusion criteria. Multivariate analyses were used to identify the predictive power of anemia for postoperative outcomes.

Results: A total of 473 adult patients undergoing elective posterior cervical fusions were identified with 106 (22.4%) diagnosed with anemia preoperatively. Anemic patients had higher rates of diabetes ($P = .0001$), American Society of Anesthesiologists scores ≥ 3 ($P < .0001$), and higher dependent functional status prior to surgery ($P < .0001$). Intraoperatively, anemic patients also had higher rates of neuromuscular injuries ($P = .0303$), stroke ($P = .013$), bleeding disorders ($P = .0056$), lower albumin ($P < .0001$), lower hematocrit ($P < .0001$), and higher international normalized ratio ($P = .002$). Postoperatively, anemic patients had higher rates of complications ($P < .0001$), death ($P = .008$), blood transfusion ($P = .001$), reoperation ($P = .012$), unplanned readmission ($P = .022$), and extended length of stay (>5 days; $P < .0001$).

Conclusions: Preoperative anemia is linked to a number of postoperative complications, which can increase length of hospital stay and increase the likelihood of reoperation. Identifying preoperative anemia may play a role in optimizing and minimizing the complication rates and severity of comorbidities following posterior cervical fusion.

Keywords
anemia, posterior cervical fusion, NSQIP, national database, complications, postoperative

Introduction

Elective cervical spine fusion surgeries have increased dramatically in prevalence and costs in the past decade.[1,2] With advancing age, there is also an increase in preoperative morbidities such as anemia, which can negatively affect clinical and surgical outcomes. Anemia has been linked to adverse outcomes in surgical procedures, including cardiovascular complications, genitourinary complications, infection, need for transfusion, increased length of stay, and readmission.[3-8] These outcomes are particularly pertinent to spinal fusion surgeries, which are typically associated with frequent use of blood

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transfusions.[9,10] Some studies have suggested that screening and subsequently reduction of preoperative anemia prior to elective surgery may improve postoperative outcomes.[4,5] With greater emphasis being placed on optimizing patient postoperative outcomes while minimizing the health care burden, it is becoming increasingly important to understand the predictive factors of surgical outcomes when considering the relative benefits and risks of posterior cervical fusion (PCF) surgery.

There is some dispute in the literature as to whether postoperative outcomes linked to anemia can be directly attributed to the anemic status of the patient, particularly in spine surgery. It has been postulated that the surgical outcomes of anemic patients are due to indirect confounding factors that are associated with anemia, such as blood transfusions and other comorbidities.[6-8,11,12] While some studies reported that anemia is not an independent predictor of postoperative complications in single-level lumbar fusions, others reported that anemia is an independent predictor for postoperative complications for patients undergoing elective spinal surgery.[8,11] Thus, it is possible that the nature of anemia as a dependent or independent predictor is a procedure-specific variable. Few studies have specifically addressed this issue in the context of PCF surgery.

Therefore, this study aims to identify correlations between preoperative anemia and postoperative outcomes in adult patients undergoing elective PCF using multivariate statistical analysis on data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. Several studies have investigated the impact of anemia on postoperative surgical outcomes in cardiac, noncardiac, orthopedic, and general spinal surgery; however, to the best of our knowledge, this article is the first to investigate the influence of anemia in PCF. The authors hypothesize that preoperative anemia will predispose patients to increased 30-day morbidity and mortality following elective PCF surgery.

Methods

Patient Selection and Data Collection

Patient data collected in the period from 2005 to 2012 from the ACS-NSQIP database was used for the present study. The methodology for definition and collection of variables in the ACS-NSQIP database has been outlined previously.[13-17] For the present study, inclusion criteria for adult surgical cases were identified based on the Current Procedural Terminology (CPT) codes for fusions at the cervical spine levels (CPT codes: 22 595 and 22 600). Exclusion criteria of the present study included those who underwent spinal deformity surgery, were underweight (body mass index <18.5 kg/m^2), were dependent on ventilator, had disseminated cancer, had received radiotherapy for malignancy within 90 days before operation, were pregnant, had tumors of the central nervous system (CNS), had received chemotherapy for malignancy within 30 days before operation, underwent emergency operations, had preoperative systemic sepsis, had nonelective surgery, had acute renal failure, had combined approaches, had concurrent anterior approach (CPT codes: 22 551, 22 554, 63 075), and had missing preoperative data. Patients were divided into 2 groups and compared: patients who had perioperative anemia versus no anemia, which was defined as a hematocrit <39% for males and <36% for females.

Explanatory and Control Variables

Patient demographic variables included sex, age (18-64 or ≥65 years), and race (white, black, Hispanic, and other). Other race included American Indian or Alaska Native, Asian, Native Hawaiian or Pacific Islander, or unknown/not reported. Preoperative variables included obesity (≥30 kg/m^2), current smoking (within 1 year of surgery), functional status prior to surgery (independent or partially/totally dependent ≤30 days prior to surgery), pulmonary comorbidity (ventilator dependent ≤48 hours prior to surgery or history of chronic obstructive pulmonary disease ≤30 days prior to surgery), cardiac comorbidity (use of hypertensive medication or history of chronic heart failure ≤30 days prior to surgery), renal comorbidity (acute renal failure ≤24 hours prior to surgery or dialysis treatment ≤2 weeks prior to surgery), diabetes, steroid use for chronic condition (≤30 days prior to surgery), ≥10% loss of body weight (in the last 6 months), bleeding disorder (chronic, active condition), preoperative transfusion of ≥1 unit of whole/packed red blood cells (≤72 hours prior to surgery) and American Society of Anesthesiologists (ASA) physical status classification (≥3).

Intraoperative variables were operative time (≥4 hours), multilevel fusions, and total relative value units. Preoperative laboratory values included albumin, hematocrit, partial thromboplastin time, and international normalized ratio.

Outcomes

Thirty-day postoperative outcome variables include mortality, any complication, wound complication (superficial or deep surgical site infection, organ space infection, or wound dehiscence), pulmonary complication (pneumonia, unplanned reintubation, or duration of ventilator-assisted respiration ≥48 hours), renal complication (progressive renal insufficiency or acute renal failure), urinary tract infection, peripheral nerve injury, cardiac complication (cardiac arrest requiring cardiopulmonary resuscitation, or myocardial infarction), intra-/postoperative transfusion, sepsis, CNS complication (cerebrovascular accident or coma), prolonged length of stay (defined as stay ≥5 days), return to the operating room for any reason within 30 days, unplanned reoperation (within 30 days, related to initial procedure), and unplanned readmission (within 30 days, related to initial procedure). ACS-NSQIP provides further information on variable characteristics.

Statistical Analysis

A bivariate analysis was performed on patient demographic, preoperative, intraoperative, and postoperative characteristics

using Pearson's χ^2 test. Fischer's exact test was used where appropriate. Continuous variables were examined using 1-way ANOVA test. Variables with a $P < .2$ in the univariate analysis were carried forward into the multivariate analysis. This specific selection criterion was used to consider as many potential risk factors as possible without compromising the validity of regression models. Multivariable logistic regression models were employed, adjusting for patient demographic, preoperative, and intraoperative variables. Regression models utilized a stepwise entry and removal criteria, set to a significance level of .05. The overall model was assessed using the C statistic, which is the area under the receiver operating characteristic curve. SAS Studio Version 3.4 (SAS Institute Inc, Cary, NC) was used for all statistical analysis.

Results

Between 2005 and 2012, a total of 473 adult patients who underwent elective PCF were identified from the ACS-NSQIP database. Of these patients, 106 (22.4%) were reported to have preoperative anemia, defined as hematocrit <39% for males and <36% for females. There was no statistically significant difference between the nonanemic and anemic groups with regard to gender (female: 46.3% nonanemic vs 41.5% anemic; male: 53.7% nonanemic vs 58.5% anemic; $P = .381$), race, and age ≥65 years.

In terms of patient clinical characteristics, there was no statistically significant difference between the nonanemic and anemic groups with regard to obesity (39.0% nonanemic vs 34.0% anemic; $P = .350$), smokers (32.7% nonanemic vs 24.5% anemic; $P = .109$), alcohol use (7.0% nonanemic vs 4.7% anemic; $P = .386$), and dyspnea (9.0% nonanemic vs 8.5% anemic; $P = .873$). However, the ASA score ≥3 was significantly higher in the anemic group (55.3% nonanemic vs 77.4% anemic; $P < .0001$). Dependent functional status prior to surgery (8.7% nonanemic vs 23.6% anemic; $P < .0001$) was also higher in the anemic group (Table 1).

There were no statistically significant differences between the nonanemic and anemic groups with regard to pulmonary comorbidities (6.5% nonanemic vs 8.5% anemic; $P = .487$), cardiac comorbidities (51.8% nonanemic vs 62.3% anemic; $P = .056$), peripheral vascular disease (1.4% nonanemic vs 2.8% anemic; $P = .302$), steroid use (3.5% nonanemic vs 4.7% anemic; $P = .558$), and recent weight loss (0.3% nonanemic vs 0.0% anemic; $P = .591$). However, in the anemic group there was a significantly higher incidence of neuromuscular injuries (7.4% nonanemic vs 14.2% anemic; $P = .030$), diabetes (13.4% nonanemic vs 29.3% anemic; $P = .0001$), stroke (3.5% nonanemic vs 9.4% anemic; $P = .013$), and bleeding disorders (1.6% nonanemic vs 6.6% anemic; $P = .006$; Table 2).

There were no significant differences in the operation time (≥4 hours) between the nonanemic and anemic groups (27.8% nonanemic vs 32.1% anemic; $P = .391$). However, there was a significant difference between the 2 groups with regard to albumin levels (4.2 g/dL nonanemic vs 3.5 g/dL anemic; $P < .0001$), hematocrit levels (42.1% nonanemic vs 34.4% anemic; $P < .0001$), and international normalized ratio levels (1.00 nonanemic vs 1.06 anemic; $P = .002$; Table 2).

Table 1. Univariate Analysis of Demographics and Clinical Characteristics Comparing Those With and Without Preoperative Anemia.[a]

	Nonanemic, N = 367		Anemic, N = 106		
	n	%	n	%	*P*
Demographics					
Sex					
Female	170	46.32%	44	41.51%	.3806
Male	197	53.68%	62	58.49%	
Race					
White	271	73.84%	73	68.87%	.6904
Black	50	13.62%	17	16.04%	
Hispanic	17	4.63%	5	4.72%	
Other	29	7.90%	11	10.38%	
Outpatient	37	10.08%	3	2.83%	
Age					
18-64	252	68.66%	62	58.49%	.0508
≥65	115	31.34%	44	41.51%	
Obese	143	38.96%	36	33.96%	.3496
ASA ≥3	203	55.31%	82	77.36%	**<.0001**
Smoke	120	32.70%	26	24.53%	.1088
Alcohol	26	7.08%	5	4.72%	.3856
Dyspnea	33	8.99%	9	8.49%	.873
Dependent functional status prior to surgery	32	8.72%	25	23.58%	**<.0001**

Abbreviation: ASA, American Society of Anesthesiologists.
[a]Bold values represent $P < .05$.

Univariate analysis revealed no statistically significant difference between the nonanemic and anemic groups in terms of renal or CNS complications (0.3% nonanemic vs 0.0% anemic; $P = .591$), cardiac complications (0.0% nonanemic vs 0.9% anemic; $P = .063$), venous thromboembolism (1.6% nonanemic vs 2.8% anemic; $P = .428$), sepsis or septic shock (0.3% nonanemic vs 1.9% anemic; $P = .065$), urinary tract infection (1.1% nonanemic vs 2.8% anemic; $P = .191$), wound complications (3.0% nonanemic vs 5.7% anemic; $P = .191$), and unplanned reoperation (2.8% nonanemic vs 6.8% anemic; $P = .194$). However, there was a significantly higher overall complication rate in the anemic patient group (6.3% nonanemic vs 19.8% anemic; $P < .0001$). Death (0.0% nonanemic vs 1.9% anemic; $P = .008$), pulmonary complications (0.8% nonanemic vs 9.4% anemic; $P < .0001$), intra- or postoperative blood transfusions (5.7% nonanemic vs 16.0% anemic; $P = .001$), return to the operating room (4.6% nonanemic vs 11.3% anemic; $P = .012$), unplanned readmission (3.3% nonanemic vs 11.4% anemic; $P = .022$), and prolonged length of hospital stay of more than 5 days (19.0% nonanemic vs 46.2% anemic; $P < .0001$) were also significantly higher in anemic patients (Table 3).

Multivariate analysis was subsequently used to quantify the predictive power of anemia on key postoperative outcomes, while controlling for the other statistically significant variables

Table 2. Comorbidities and Operative Variables for Those With and Without Preoperative Anemia.[a]

	Nonanemic, N = 367		Anemic, N = 106		
	n	%	n	%	*P*
Comorbidities					
Pulmonary comorbidity	24	6.54%	9	8.49%	.4873
Cardiac comorbidity	190	51.77%	66	62.26%	.0562
Peripheral vascular disease	5	1.36%	3	2.83%	.3019
Diabetes	49	13.35%	31	29.25%	**.0001**
Neuromuscular injury	27	7.36%	15	14.15%	**.0303**
Stroke	13	3.54%	10	9.43%	**.013**
Steroid use	13	3.54%	5	4.72%	.5576
Recent weight loss	1	0.27%	0	0.00%	.5906
Bleeding disorder	6	1.63%	7	6.60%	.0058
Operative Variables and Labs	Mean	SD	Mean	SD	
Albumin	4.2	0.4	3.49	0.6	**<.0001**
HCT	42.07	3.14	34.42	3.66	**<.0001**
PTT	29.23	4.39	30.12	5.81	.1976
INR	1	0.12	1.06	0.16	**.0019**
Total RVU	54.17	27.71	53.99	31.74	.9549
Procedure Subtypes	n	%	n	%	
Multilevel fusion	250	68.12%	72	67.92%	.9697
Operative time >4 hours	102	27.79%	34	32.08%	.3908

Abbreviation: HCT, hematocrit; PTT, partial thromboplastin time; INR, international normalized ratio; RVU, relative value unit.
[a]Bold values represent $P < .05$.

Table 3. Univariate Analysis of Complications Between Cohorts.[a]

Outcome	Nonanemic, N = 367		Anemic, N = 106		*P*
	n	%	n	%	
Complications					
Any complication	23	6.27%	21	19.81%	**<.0001**
Death	0	0.00%	2	1.89%	**.0084**
Pulmonary complication	3	0.82%	10	9.43%	**<.0001**
Renal complication	1	0.27%	0	0.00%	.5906
CNS complication	1	0.27%	0	0.00%	.5906
Peripheral nerve injury	1	0.27%	0	0.00%	.5906
Cardiac complication	0	0.00%	1	0.94%	.0625
PE/DVT	6	1.63%	3	2.83%	.4275
Sepsis/septic shock	1	0.27%	2	1.89%	.0652
Intra-/postoperative blood transfusion	21	5.72%	17	16.04%	**.0006**
UTI	4	1.09%	3	2.83%	.1912
Wound complication	1	3.00%	6	5.66%	.1945
Graft/flap failure	1	0.27%	0	0.00%	.5906
Other outcomes					
Return to operating room	17	4.63%	12	11.31%	**.0115**
Unplanned reoperation (2011-2012)	6	2.84%	3	6.82%	.1937
Unplanned readmission (2011-2012)	7	3.31%	5	11.36%	**.0219**
Prolonged length of stay ($\geq$5 days)	70	19.04%	49	46.23%	**<.0001**

Abbreviation: CNS, central nervous system; PE, pulmonary embolism; DVT, deep vein thrombosis; UTI, urinary tract infection.
[a]Bold values represent $P < .05$.

identified through the aforementioned univariate analysis. Preoperative anemia was a statistically significant predictor of the following: any postoperative complication generally (odds ratio [OR] = 3.14; 95% confidence interval [CI] = 1.61-6.12; $P = .001$), pulmonary complications (OR = 9.74; 95% CI = 2.55-37.23; $P = .001$), the need for intra- or postoperative blood transfusion(s) (OR = 3.06; 95% CI = 1.50-6.25; $P = .002$), return to operating room (OR = 2.87; 95% CI = 1.30-6.31; $P = .009$), and extended length of stay $\geq$5 days (OR = 2.86; 95% CI = 1.76-4.66; $P < .0001$; Table 4).

Discussion

PCF is a commonly performed procedure for a variety of spine deformities such as spondylolisthesis and degenerative disc disease.[2,18] Given the growing elderly population and prevalence of spinal procedures performed in the past decade, there is an increasing emphasis of careful patient selection for surgery so as to optimize postoperative outcomes.[14,19-21] There have been few studies investigating the specific role of preoperative anemia of postoperative outcomes.

Our study demonstrated that preoperative anemia was a strong predictor of the number of postoperative complications and correlated with the need for intra- or postoperative blood transfusions, pulmonary complications, and reoperation. The link between preoperative anemia and the need for blood transfusions is expected as surgical blood loss can exacerbate anemic patients with preoperatively compromised hematocrit levels. This is particularly true of spinal fusion surgeries, which are often associated with a need for blood transfusion.[9,10] Dunne et al[4] also reported that noncardiac surgical patients with anemia received 5 times more blood transfusions than nonanemic patients, and that this has been linked with an increased risk of infection, mortality, and respiratory complications. This finding is in line with our observation that there was no difference in preoperative pulmonary comorbidities and dyspnea between the anemic and nonanemic groups, but a significant increase in postoperative pulmonary complications in the anemic group.

There was no statistically significant difference between the anemic and nonanemic groups with regard to demographic features, suggesting that the 2 groups were well balanced with few confounding factors and thus low selection bias with regard to these factors. However, there were differences between the 2 groups with regard to clinical characteristics and comorbidities, specifically, ASA score, diabetes, dependent functional status, neuromuscular injuries, and stroke. It was therefore important to account for these factors in the multivariate analyses. We were able to reduce bias associated with confounding and hence isolate the effect of preoperative anemia on postoperative outcomes by introducing control variables for these factors.

Table 4. Multivariate Regression Analysis of Anemia as Independent Risk Factor.

Multivariate Analysis of Anemia on Any Complications, N = 473				
Effect	Estimate	95% Confidence Limits		*P*
Anemia	3.136	1.608	6.116	.0008
ASA ≥3	3.849	1.556	9.52	.0035
Multivariate Analysis of Anemia on Mortality, N = 473				
Effect	Estimate	95% Confidence Limits		*P*
Anemia	>999.999	<0.001	>999.999	.9092
Multivariate Analysis of Anemia on Pulmonary Complications, N = 473				
Effect	Estimate	95% Confidence Limits		*P*
Anemia	9.745	2.551	37.227	.0009
Dependent functional status	4.106	1.258	13.402	.0193
Multivariate Analysis of Anemia on Intra-/Postoperative Transfusion, N = 473				
Effect	Estimate	95% Confidence Limits		*P*
Anemia	3.063	1.502	6.245	.0021
Age >65	2.578	1.274	5.218	.0085
Weight loss	62.178	30.038	128.705	<.0001
Operative time >4 hours	6.218	3.016	12.822	<.0001
Multivariate Analysis of Anemia on Return to OR, N = 473				
Effect	Estimate	95% Confidence Limits		*P*
Anemia	2.87	1.305	6.311	.0087
Alcohol	3.92	1.35	11.382	.012
Dyspnea	2.74	1.022	7.349	.0452
Steroid	3.834	1.077	13.654	.0381
Weight loss	7.905	1.634	38.239	.0102
Multivariate Analysis of Anemia on 30-Day Readmissions, N = 473				
Effect	Estimate	95% Confidence Limits		*P*
Anemia	2.894	0.857	9.777	.0871
Diabetes	5.252	1.579	17.475	.0068
Weight loss	122.023	37.63	395.681	<.0001
Multivariate Analysis of Anemia on LOS >5, N = 473				
Effect	Estimate	95% Confidence Limits		*P*
Anemia	2.863	1.758	4.662	<.0001
Obesity (BMI >30)	0.498	0.306	0.81	.005
ASA ≥3	2.886	1.72	4.842	<.0001
Neuromuscular injury	2.793	1.388	5.617	.004
Operative time > 4 hours	1.622	1.008	2.61	.0464

Abbreviations: ASA, American Society of Anesthesiologists; OR, operating room; LOS, length of stay; BMI, body mass index.

Preoperative anemia is also associated with an extended length of hospital stay. This outcome was measured using an indicator variable for patients with a length of stay greater than 5 days. It was found that this indicator variable produced a high and statistically significant odds ratio (OR = 2.86; $P < .0001$), even when controlling for a number of confounding factors. This suggests that anemic patients require more time postoperatively to meet the discharge requirements and/or they have other postoperative complications, which impede their rate of recovery. These results are corroborated by the findings of other studies that reported that iron supplementation for anemic total hip replacement patients reduced the need for transfusions and thus can potentially be used for spinal surgery patients too.[4] Ultimately, the extended length of stay is an important postoperative outcome to consider when deciding whether to proceed with surgery because it is directly associated with increased financial costs and a higher burden on health care resource consumption.

To date, there are conflicting reports in the literature as to whether preoperative anemia is an independent risk factor for postoperative complications. It has been postulated that anemia only influences postoperative outcomes indirectly through other factors such as the need for blood transfusions; however, some studies have identified statistically significant correlations between anemia and complications even when accounting for such confounding factors. Kim et al[7] reported that anemia is not an independent predictor of postoperative complications, mortality, or increased length of stay following single-level lumbar fusions. By controlling for confounding factors, especially transfusions, they found no direct link between anemia and these complications. However, they noted the need for validation of their finding in other spinal surgical procedures. The increased prevalence of age with anemia may also be attributed to the greater complications in the anemic group, as older patients are more likely to suffer from chronic diseases and other morbidities that can adversely affect operative outcomes.

Conversely, Seicean et al[21] investigated the impact of anemia on surgical outcomes in patients undergoing elective spine surgery and reported a direct link between anemia and

prolonged length of hospital stay and increased likelihood of experiencing postoperative complications. They also reported that anemia is an independent predictor of outcomes beyond what is explicable by anemia-driven blood transfusions. The mechanisms driving this direct link may be attributed to the lower oxygen carrying capacity of anemic patients. The lower oxygen carrying capacity may cause hypoxia, which can manifest as reduced cardiac perfusion and impaired wound healing, explaining the higher complication rates in anemic patients.[22,23] The dispute with regard to whether anemia is directly or indirectly correlated with postoperative outcomes can potentially be attributed to procedure-specific differences. Nevertheless, anemia is still correlated with postoperative outcomes regardless of whether or not it is an independent predictor. Thus, screening for and subsequently improving the anemia status of patients prior to surgery is likely to improve the postoperative outcomes by reducing the need for intra- and postoperative blood transfusions and reducing the severity of other comorbidities linked to anemia.[3,5,6]

It is important to address the limitations of the current study. First, anemia has been measured as an indicator variable as opposed to a continuous variable, which limits our ability to identify correlations between outcomes and the severity of the anemia.[24] It is likely that the severity of anemia would vary nonlinearly with postoperative complications, with severe anemia having significantly poorer outcomes than mild anemia. However, this has not been measured in this study. Second, there are several relevant factors that are not recorded in the ACS-NSQIP database. For example, neither volume of blood lost during the procedure nor the volume of blood transfused have been recorded. These would be pertinent in identifying the role of blood loss during surgery in the progression of anemia and hence the development of poorer outcomes. Similarly, other missing variables associated with patient demographics and comorbidities reduce our ability to mitigate confounding through control variables. Third, it is important to acknowledge that a number of the assessed preoperative comorbidities (such as peripheral vascular disease) and postoperative outcomes (such as renal, cardiac, and CNS complications) may have been identified as not statistically significant only because of a lack of statistical power. This may have been caused by the low incidences of these variables in the measured sample of the population, and hence the small sample sizes reduced statistical power in the analysis. A larger sample from the population would be required to increase statistical power to confirm whether or not these comorbidities and outcomes are important. Finally, the correlation between anemia and adverse postoperative outcomes is complex and contains many confounding variables. Through multivariate logistic regression analysis and the power of the ACS-NSQIP database that collects $\sim$150 patient demographic, preoperative, intraoperative, and postoperative variables, several potentially confounding factors were controlled for. However, there still exists variables that were not considered in the analysis that may play a role in the association of anemia with postoperative outcomes association. The authors withhold their recommendation to treat preoperative anemia as a method to avoid postoperative outcomes until further studies can corroborate the present results.

Conclusions

In this study, we have identified the links between preoperative anemia and postoperative outcomes in adult patients undergoing elective PCF. Preoperative anemia was associated with a higher rate of postoperative complications, specifically pulmonary complications, along with the greater need for blood transfusions, reoperation, and increased length of hospital stay. It is likely that improving a patient's anemia status prior to surgery will improve surgical outcomes and reduce complications either directly or indirectly by reducing the severity of other comorbidities and need for blood transfusions.

Authors' Note

This study was qualified as exempt by the Mount Sinai Hospital Institutional Review Board.

Declaration of Conflicting Interests

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