

Impact of Iron Deficiency Anemia on Postoperative Outcomes of Thoracolumbar Spinal Fusion (2+ levels) on Patients with Adult Spinal Deformity with Minimum 2-Year Follow-Up

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Abstract:

Introduction: Iron deficiency anemia (IDA) is a common hematological disorder and cause of low hemoglobin. Preoperative anemia has been demonstrated to increase the risk of adverse outcomes after posterior cervical fusion and other spinal surgeries. The need for a transfusion during lumbar fusion has been shown to increase length of stay. This study aimed to assess the impact of IDA on outcomes after spinal fusion for adult spinal deformity (ASD).

Methods: The New York Statewide Planning and Research Cooperative System (SPARCS) database was searched from 2009 to 2013 to identify all patients undergoing ≥2-level thoracolumbar spinal fusion (primary and revision) for ASD with a 2-year follow-up. The patients were then stratified by the presence or absence of IDA. Patients with IDA and patients without IDA were subjected to 1:1 propensity score matching based on age, sex, and obesity. Univariate analysis was employed to compare demographics, hospital parameters, and rates of adverse outcomes. Multivariate binary logistic regression with odds ratio (OR) was employed to identify independent risk factors for adverse postoperative outcomes.

Results: A total of 524 patients (262 with IDA and 262 without IDA) were identified. Patients with IDA experienced higher rates of overall surgical complications (50.4% vs 23.7%, $P<0.001$), wound complications (3.4% vs 0.4%, $P=0.011$), and blood transfusion (10.3% vs 6.5%, $P<0.001$). No difference was observed in the rate of overall medical complications. Patients with and without IDA had comparable rates of readmission (8.0% vs 13.0%, $P=0.064$), although patients with IDA had lower rates of reoperation (7.6% vs 13.0%, $P=0.044$). There was no mortality in either cohort. IDA was independently associated with wound complications (OR=10.6, $P=0.028$), blood transfusion (OR=3.9, $P<0.001$), and surgical complications (OR=3.5, $P<0.001$).

Conclusions: Baseline IDA was predictive of increased wound complications, postoperative blood transfusion, and overall surgical complications after thoracolumbar fusion surgery for ASD. Our findings could inform potential medical interventions to mitigate the risks of adverse outcomes in patients with IDA.

Level of Evidence: III, retrospective cohort

Keywords:

SPARCS, Thoracolumbar Fusion, Spinal Fusion, Iron Deficiency Anemia, Adult Spinal Deformity, Outcomes

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Introduction

Iron deficiency anemia (IDA) is characterized by a low blood hemoglobin and/or hematocrit secondary to low availability of iron in the body¹⁾. Previous studies have identified an association between anemia and adverse outcomes after surgical procedures, such as increased risk of infection, increased length of stay (LOS), increased readmission rates,

and need for transfusion^{2,3)}. This finding is particularly important in spinal procedures, which are often associated with transfusions due to increased blood loss⁴⁾. Therefore, the identification of anemia can be considered a crucial part of preoperative planning to best optimize the patient for surgery.

Previous studies have found that anemia adversely impacts outcomes after cervical spinal fusions, resulting in in-

Table 1. ICD-9 Diagnosis/Procedure Codes.

Diagnosis/Procedure	ICD-9 Codes
Medical complications	
Altered mental status	78097
Acute myocardial infarction	410 9971
Pulmonary	9973 99731 99732 51851 51852 51853
Pneumonia	480 4801 4802 4803 4804 4805 4806 4807 4808 4809 481 4821 4822 4823 4824 4825 4826 4827 4828 4829 4829 483 4831 4838 484 4841 4843 4845 4846 4847 4848 485 486 487 507
Gastrointestinal	9974
Urinary tract infection	599 9975
Acute renal failure	5845 5846 5847 5848 5849
Sepsis	99591 99592
Pulmonary embolism	41511 41513 41519
Deep venous thrombosis	45111 45119 4512 45181 45340 45341 45342
Cerebrovascular event	430 431 4320 4321 4329 43300 43301 43310 43311 43320 43321 43330 43331 43380 43381 43390 43391 43400 43401 43410 43411 43490 43491
Surgical complications	
Wound	9981 99811 99812 99813 9983 99831 99832 99883 9985 9993 99851 99859
CNS	99709 99701 99700
Dural tear	3493 34939
Blood transfusion	9903 9904 9905 9907
Revision of ≥ 2 -level thoracolumbar spinal fusion	8100 8104 8105 8106 8107 8108 8130 8134 8135 8136 8137 8138 8163 8164

creased risks of overall complications, including stroke and pulmonary complications⁹. Various studies have reported the effect of different comorbidities on postoperative outcomes after lumbar spinal surgery, such as end-stage renal disease or lumbar trauma^{6,8}). However, few, if any, studies have examined anemia as a preoperative risk factor for complications after lumbar spinal surgery. The effect of preoperative anemia on thoracolumbar spinal fusion is not well described in the literature. Therefore, this study contributes to the lack of literature by comparing the outcomes and complication rates between adult spinal deformity (ASD) patients with and without IDA undergoing ≥ 2 -level thoracolumbar spinal fusion.

This study aimed to characterize postoperative outcomes in patients with IDA compared with those without IDA among patients who underwent thoracolumbar spinal fusion for ASD. We hypothesize that compared with patients without IDA, those with IDA who underwent thoracolumbar fusion for ASD have higher rates of adverse postoperative medical and surgical outcomes.

Materials and Methods

Data source

Using the New York Statewide Planning and Research Cooperative System (SPARCS) database, a retrospective analysis was conducted. The SPARCS database is a collaborative effort containing information on patient-level discharge information. It is available through the New York State Department of Health Informatics and collects information from all patients in New York state. The database

contains information on both outpatient and inpatient visits, including all ambulatory surgery visits as well as hospital and emergency department admissions. The information collected includes patient characteristics, their diagnoses and treatments, as well as the services and charges they received⁹. As a publicly available database, the study was exempted by the State University of New York Downstate Health Sciences University Institutional Review Board.

Patient population

Patients aged ≥ 18 years were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnoses and procedure codes. Those who underwent ≥ 2 -level (ICD-9-CM procedure codes 81.62, 81.63, and 81.64) thoracolumbar spinal fusion for any indication (ICD-9-CM procedure codes 81.04, 81.05, 81.06, 81.07, 81.08, 81.34, 81.35, 81.36, 81.37, and 81.38) for ASD (ICD-9-CM diagnosis codes 737.30) from January 1, 2009, to December 31, 2011, were identified. The patients were then split based on the presence of IDA (binary yes/no based on ICD-9-CM diagnosis codes 280.1, 280.8, and 280.9) at the time of surgery. Patients with IDA were subjected to 1:1 propensity score matching with controls (patients without IDA) based on age, sex, and obesity status.

Outcome measures

Using the ICD-9 diagnosis and procedure codes, we evaluated the frequency of medical and surgical complications within the 2-year period after the index thoracolumbar spinal fusion procedure (Table 1). In addition, outcomes including LOS, total hospital charge, mortality, reoperation, and readmission were evaluated.

Table 2. Demographics of Patients in the Iron Deficiency Anemia (IDA) and No-IDA Cohorts.

Variable	Yes IDA N (%)	No IDA N (%)	P-value
Total (N)	262 (50%)	262 (50%)	
Sex			1.000
Male	53 (20.2%)	53 (20.2%)	
Female	209 (79.8%)	209 (79.8%)	
Race			
White:	182 (69.5%)	230 (88.1%)	<0.001
Black:	38 (14.5%)	27 (10.3%)	
Hispanic:	19 (7.3%)	1 (0.4%)	
Asian:	6 (2.3%)	0 (0.0%)	
American Indian:	1 (0.4%)	0 (0.0%)	
Other:	16 (6.1%)	3 (1.1%)	
Pay			
Medicare:	91 (34.7%)	115 (43.9%)	0.008
Medicaid:	12 (4.6%)	24 (9.2%)	
Private insurance:	111 (42.4%)	80 (30.5%)	
Self-pay:	2 (0.8%)	0 (0.0%)	
No charge:	0 (0.0%)	0 (0.0%)	
Other:	46 (17.6%)	43 (16.4%)	
Obesity			
No	228 (87.0%)	228 (87.0%)	1.000
Yes	34 (13.0%)	34 (13.0%)	
Age (years)	56.80±13.625	56.80±13.625	1.000
Deyo score	0.70±1.172	0.76±1.028	0.553
Total length of stay (days)	5.98±4.436	4.00±4.326	<0.001
Total surgical charges (\$)	95,673.60±69,059.995	59,536.90±39,753.217	<0.001

Statistical analyses

All statistical analyses were conducted using SPSS version 27 (IBM Corporation, Armonk, New York). Univariate analyses were conducted to assess demographics, hospital parameters, and rates of adverse outcomes. Pearson’s chi-squared test was employed to analyze the rates of complications between the cohorts. Student’s t-test was employed to compare patients’ ages. Multivariate binary logistic regression was employed to identify independent predictors of adverse outcomes. A p-value <0.05 was considered statistically significant.

Results

Patient demographics

A total of 524 patients (262 with IDA and 262 without IDA) were identified. No difference was observed in age, sex, or obesity between the cohorts (all P=1.0) (Table 2). In addition, the Deyo score was similar between the cohorts (P=0.553) (Table 2). Patients with IDA were more likely to have private insurance compared to patients without IDA (42.4% versus 30.5%, P=0.008). Fewer patients with IDA identified as white compared to those without (69.5% versus 88.1%, P<0.001) (Table 2). Patients with IDA also had higher surgical charges (\$95,673.60 versus \$59,536.90) and LOS (5.98 versus 4.00 days) (all P<0.001) (Table 2).

Univariate analyses

Crude analysis revealed a higher rate of overall surgical complications (P<0.001), wound complications (P=0.011), and blood transfusion in patients with IDA (P<0.001) (Table 3). Crude analysis revealed that patients without IDA had a higher incidence of reoperation (P=0.044) (Table 3). No difference was observed in the rate of overall medical complications between the two cohorts (all P>0.055) (Table 3). Patients without IDA had a higher, though nonsignificant, re-admission rate compared to those with IDA (P=0.064) (Table 3). In addition, there was no mortality in either cohort (Table 3).

Multivariate analyses

The adjusted analysis revealed that IDA was a risk factor for surgical complications (odds ratio [OR]=3.5, 95% confidence interval [CI]=2.4, 5.2, P<0.001) (Table 4). Specifically, patients with IDA had a higher risk of wound complications (OR=10.6, 95% CI=1.3, 86.5, P<0.001) and blood transfusion (OR=3.9, 95% CI=2.6, 6.0, P<0.001) (Table 4). The adjusted analysis revealed that IDA was not associated with increased odds for reoperation (OR=0.5, 95% CI=0.3, 1.0, P=0.046) or readmission (OR=0.5, 95% CI=0.3, 1.0, P=0.045) (Table 4).

Table 3. Impact of Iron Deficiency Anemia on the Rate of Postoperative Outcomes on Adult Spinal Deformity Patients Undergoing ≥ 2 -Level Thoracolumbar Spinal Fusion).

Postoperative Outcome	Yes IDA N (%)	No IDA N (%)	P-Value
Surgical complications (any)	132 (50.4%)	62 (23.7%)	<0.001
Wound	9 (3.4%)	1 (0.4%)	0.011
CNS	1 (0.4%)	0 (0.0%)	0.317
Dural tear	1 (0.4%)	1 (0.4%)	1.000
Transfusion of blood	120 (45.8%)	50 (19.1%)	<0.001
Medical complications (any)	27 (10.3%)	17 (6.5%)	0.115
Altered mental status	0 (0.0%)	0 (0.0%)	-
Acute myocardial infarction	8 (3.1%)	2 (0.8%)	0.055
Pulmonary	0 (0.0%)	0 (0.0%)	-
Pneumonia	3 (1.1%)	4 (1.5%)	0.704
Gastrointestinal	3 (1.1%)	2 (0.8%)	0.653
Urinary tract infection	3 (1.1%)	1 (0.4%)	0.315
Acute renal failure	8 (3.1%)	7 (2.7%)	0.793
Sepsis	1 (0.4%)	0 (0.0%)	0.317
Pulmonary embolism	2 (0.8%)	1 (0.4%)	0.563
Deep venous thrombosis	1 (0.4%)	1 (0.4%)	1.000
Cerebrovascular event	0 (0.0%)	2 (0.8%)	0.157
Reoperation	20 (7.6%)	34 (13.0%)	0.044
Revisions	0 (0.0%)	0 (0.0%)	-
Readmission any	21 (8.0%)	34 (13.0%)	0.064
Mortality (hospitalization)	0 (0.0%)	0 (0.0%)	-

Discussion

Anemia is a well-known risk factor for adverse outcomes after surgery, including infection, increased length of hospital stay, increased rate of readmission, and increased risk for blood transfusion and transfusion-associated complications^{10,11}. Previous studies have found a negative association between anemia and overall complications after cervical spinal fusions¹². However, the effect of anemia on thoracolumbar spinal fusion has not been fully characterized. The rates of overall surgical complications, wound complications, and blood transfusions were higher among patients with IDA who underwent thoracolumbar spinal fusion for ASD. Furthermore, these patients had greater LOS and surgical charges overall. After controlling for confounders and effect modifiers, multivariable adjusted analyses revealed that IDA was an independent risk factor for overall surgical complications, wound complications, and blood transfusion.

Previous literature has shown an association between anemia and risk of readmission, greater LOS, and risk of transfusion after adult spinal surgery^{13,14}. However, few studies have examined the role of anemia in patients after multilevel spinal fusion. Choy et al. identified anemia and kidney failure as indicators of readmission after posterior cervical fusion¹³. However, this study only focused on readmission rates and posterior cervical fusion, not thoracolumbar spinal fusion. In addition, only 30-day readmission rates were identified. Mo et al. found an increased risk of postoperative transfusion and LOS in patients with severe anemia and ASD who underwent spinal fusion¹⁴. Nonetheless, this study

did not focus on thoracolumbar spinal fusion, and complications were measured at only 30 days postoperatively. One recent study by Elsamadicy et al. found a significant increase in LOS, hematoma formation, and infection in elderly male patients with ≥ 3 -level spinal fusion¹⁵. In this study, only elderly males were included, and the readmission rates were assessed only at 30 days postoperatively. Notably, these studies define anemia based on hemoglobin levels according to the World Health Organization classification¹³⁻¹⁵. Despite the limitations, these studies provide valuable information on anemia as a risk factor in patients undergoing spinal fusion. Although our study also identified an increased risk of LOS and blood transfusion, we specifically investigated IDA, which can present with low-normal hemoglobin levels.

Some recent studies have not identified an association between anemia and negative postoperative outcomes after adult spinal surgery. Several studies found that increasing anemia severity does not correlate with overall postoperative complications¹⁶⁻¹⁸. Nabi et al. found that postoperative anemia was not associated with early hospital readmission in patients who underwent fusion for ASD¹⁶. However, this study focused on postoperative anemia, not preoperative anemia, and did not specifically evaluate thoracolumbar spinal fusion outcomes. In addition, Schwab et al. found no association between anemia and complication rates in patients with ASD undergoing surgery¹⁷. However, this study did not specifically focus on patients undergoing thoracolumbar spinal fusion or >2 -level fusion. This discrepancy could be explained by the type of spinal surgery performed. Kim et al.

Table 4. Impact of Iron Deficiency Anemia on the Risk of Postoperative Outcomes on Adult Spinal Deformity Patients Undergoing ≥ 2 -Level Thoracolumbar Spinal Fusion.

Variables	OR [CI] (Crude)	<i>P</i>	OR [CI] (Adjusted)	<i>P</i>
Surgical complications	3.3 [2.3, 4.8]	<0.001	3.5 [2.4, 5.2]	<0.001
Wound	9.3 [1.2, 73.8]	0.035	10.6 [1.3, 86.5]	0.028
CNS	-	0.995	-	0.992
Dural tear	1.0 [0.1, 16.1]	1.000	1.2 [0.1, 20.4]	0.893
Transfusion of blood	3.6 [2.4, 5.3]	<0.001	3.9 [2.6, 6.0]	<0.001
Medical complications	1.7 [0.9, 3.1]	0.118	1.5 [0.8, 3.0]	0.200
Altered mental status	-	-	-	-
Acute myocardial infarction	4.1 [0.9, 19.5]	0.076	4.0 [0.8, 19.7]	0.086
Pulmonary	-	-	-	-
Pneumonia	0.7 [0.2, 3.4]	0.705	0.3 [0.1, 2.0]	0.229
Gastrointestinal	1.5 [0.3, 9.1]	0.655	1.4 [0.2, 9.3]	0.731
Urinary tract infection	3.0 [0.3, 29.3]	0.339	4.0 [0.4, 39.1]	0.239
Acute renal failure	1.1 [0.4, 3.2]	0.793	1.1 [0.3, 3.4]	0.884
Sepsis	-	0.995	-	0.995
Pulmonary embolism	2.0 [0.2, 22.3]	0.570	2.7 [0.2, 30.9]	0.424
Deep venous thrombosis	1.0 [0.1, 16.1]	1.000	4.4 [0.1, 142.4]	0.409
Cerebrovascular event	-	0.995	-	0.993
Reoperation	0.6 [0.3, 1.0]	0.047	0.5 [0.3, 1.0]	0.046
Revisions	-	-	-	-
Readmission any	0.6 [0.3, 1.0]	0.1	0.5 [0.3, 1.0]	0.045
Mortality (hospitalization)	-	-	-	-

specifically examined patients who underwent single-level fusion procedures¹⁸⁾, which could be associated with fewer complications by nature of the less complex procedure. Further research is warranted to investigate this association. Finally, none of these studies examined IDA specifically.

Our study identified a higher rate of postoperative complications in patients with IDA. Although the exact mechanism of this finding is unknown, the authors presumed that a reduction in hemoglobin levels due to IDA may lead to a decreased capacity for oxygen transport to bodily tissues. Such a reduction can slow down wound healing and increase the risk of infections as adequate oxygenation is crucial for immune function and tissue repair. Moreover, patients with IDA may be more susceptible to experiencing higher volumes of blood loss during surgery, necessitating more frequent blood transfusions. These transfusions may increase the risk of transfusion reactions and infections, potentially contributing to an increased complication rate. Further associations between IDA and postoperative complications after PSF warrant further study in larger retrospective and prospective cohorts.

Our study had several limitations. Inherent with large databases, clerical errors may impair data accuracy. Furthermore, the granularity of diagnoses, procedures, and complications has limitations per ICD-9-CM coding schema as well as the data collected. For example, the severity of IDA is not identifiable in the database. Also, the database does not list out the ASD or IDA criteria but rather indicates whether a patient carries the diagnosis or not based on ICD-9 coding. The lack of Scoliosis Research Society (SRS)-Schwab classification is another limitation of the database.

In addition, the database does not specify the indication for the ≥ 2 -level thoracolumbar spinal fusion performed. Other nutritional deficiencies also could not be controlled for due to limitations of the database. Finally, the database is specific for admissions that occurred in New York state. While the state has a diverse patient population, the generalizability of study findings may have limitations secondary to locality. Nevertheless, our findings provide additional insight into the effects of IDA on thoracolumbar spinal fusion in patients with ASD.

These results raise the question regarding the role of medical optimization in patients with IDA prior to spinal fusion. Our findings argue in favor of iron supplementation to reduce the risk of overall medical and surgical complications. Various studies have reported the benefits of intravenous iron administration for patients with IDA prior to major surgery¹⁹⁻²¹⁾, citing the overall scarcity of allogenic blood transfusions and their associated risk of infection, cardiac complications, and overall mortality¹⁹⁾. The literature on iron prophylaxis in orthopedics is inconclusive. While some studies have found an overall increase in postoperative hemoglobin levels after intravenous iron or ferrous carboxymaltose (an iron replacement supplement) prior to orthopedic procedures^{20,21)}, others have found no benefit for either therapy in reducing postoperative blood transfusions²²⁻²⁴⁾. Future prospective studies are warranted to better understand how medical interventions, such as elemental supplementation, may affect postoperative outcomes among patients with IDA who undergo thoracolumbar fusion for ASD. We also advocate for further multicenter studies across multiple hospital systems to elucidate the effect of iron supplementation pro-

phylaxis.

Compared to patients without IDA, those with IDA who underwent ≥ 2 -level thoracolumbar spinal fusion for ASD had higher risks of overall surgical complications, wound complications, and blood transfusion. Patients with IDA had higher LOS and hospital charge rates than those without IDA. Further research on the role of iron prophylaxis for patients with IDA undergoing orthopedic procedures is warranted, as these preliminary results argue in favor of optimization of iron levels to reduce medical and surgical complications.

Conflicts of Interest:

Olivia Christina Tracey, BA: Associate Editor, Journal of Orthopaedic Experience & Innovation. I am a part-time, non-paid Copy Editor (grammar and style) for submitted manuscripts. My role has no bearing on what is ultimately published in the journal.: Editorial or governing board

Carl B Paulino, MD, FAAOS, FAOrthA: DePuy, A Johnson & Johnson Company Ethicon: Paid presenter or speaker

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Author Contributions:

Alex C. Jung - designed the study, manuscript writing, data analysis

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Neil Shah - manuscript revision

Carl Paulino - supervised the study

Jad Bou Monsef - supervised the study

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Informed Consent: Consent was not required because this study de-identified all patients.

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