Data-Driven Preoperative Hemoglobin Strata that Maximize the Likelihood of Blood Transfusion following Single-Level Lumbar Fusion are also Predictive of Major Complications and Deep Infections

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INTRODUCTION:

There has been a recent push to preoperatively and intraoperatively optimize patients undergoing single-level lumbar spine fusion to reduce the use of blood transfusions due to its association with increased risk of major complications and deep infection. Current hemoglobin thresholds for anemia severity, which are the most predictive preoperative variable associated with blood transfusions, are based on research published in 1968 and are not surgery specific. The purpose of this study was to determine data-driven preoperative hemoglobin strata, specific to single-level lumbar spine fusion, that maximized the likelihood of 90-day blood transfusion and to observe whether the identified strata are associated with an increased risk of 90-day major complications and 2-year deep infection.

METHODS:

A retrospective cohort analysis was performed using a national database to identify patients undergoing primary single-level lumbar fusion between 2013 to 2022 with a hemoglobin value within 30 days of surgery. Exclusion criteria included a history of malignancy, less than 2-year follow up, and fusion indicated for fracture. Patients were stratified based on sex to identify sex-based strata. Stratum-specific likelihood ratio (SSLR) analysis was used to define hemoglobin strata associated with the risk of 90-day blood transfusion risk after lumbar fusion. SSLR is a modified approach to analyzing Receiver Operating Characteristics (ROC) curves that allows for the identification of multiple data-driven strata that optimize differences in the likelihood of complications. Each identified stratum was then propensity-score matched to the highest identified hemoglobin strata based on age, sex, hypertension, heart failure, chronic obstructive pulmonary disease, diabetes mellitus, and obesity. The risk ratio (RR) for each stratum with respect to the lowest matched stratum was observed. Incidence rates, via unmatched analysis, and risk, via matched analysis, of 90-day major complications and 2-year deep infection between strata was observed.

RESULTS:

In total, 17,310 patients met inclusion criteria. SSLR identified three female hemoglobin strata for 90-day blood transfusion [Strata, Likelihood ratio (5.0-10.9, 2.41; 11.0-12.4, 1.35; 12.5-17.0, 0.78)] and three male hemoglobin strata for 90-day transfusion (5.0-11.9, 2.95; 12.0-13.4, 1.46; 13.5-13.9, 0.71). After matching, the risk of 90-day blood transfusion for females increased sequentially as the hemoglobin strata decreased (11.0-12.4 [RR: 1.59, p<0.001], 5.0-10.9 [RR 2.79, p<0.001]) when compared to the highest hemoglobin strata (12.5-17). The risk of 90-day blood transfusion for males increased sequentially as the hemoglobin strata decreased (12.0-13.4 [RR: 1.50; p=0.014], 5.0-11.9 [RR: 2.68; p<0.001]) when compared to the highest hemoglobin strata (13.5-13.9). Two female strata had a significantly increased risk of 90-day major complications (11.0-12.4 [RR: 1.52; p<0.001], 5.0-10.9 [RR: 3.40; p<0.001]) and one female stratum had a significantly increased risk of 2-year deep infection (5.0-10.9 [RR: 3.67; p<0.001]). One male stratum had a significantly increased risk of 90-day major complications (5.0-11.9 [RR: 2.02; p<0.001]) and one male stratum had a significantly increased risk of 2-year deep infection (5.0-11.9 [RR: 2.11; p=0.005]).

DISCUSSION AND CONCLUSION:

SSLR analysis was successful in establishing single-level lumbar fusion-specific data-driven male and female hemoglobin strata that both maximize the likelihood of 90-day blood transfusions and predict the risk of 90-day major complication and 2-year deep infection. When optimizing patients in the preoperative setting, we recommend using our single-level lumbar fusion-specific hemoglobin thresholds, noting the sequential increase in risk of major complications, deep infection, and blood transfusion requirements starting with a hemoglobin of less than 13.5 in males and 12.5 in females.
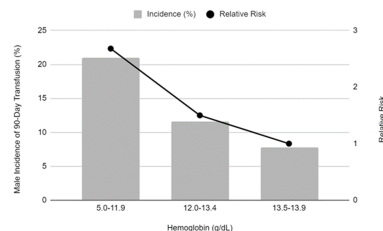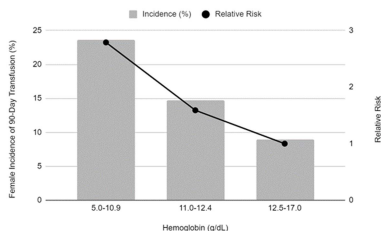
Table 1. Stratum Specific Likelihood Ratio Analysis For 90-day Blood Transfusion Based On Hgb Strata

| | Hemoglobin Thresholds | | | | | |
| | Male | | | Female | | |
	5.0-11.9	12.0-13.4	13.5-13.9	5.0-10.9	11.0-12.4	12.5-17.0
Likelihood Ratios (LR)	2.95	1.46	0.71	2.41	1.35	0.78
LR Lower 95% CI	2.47	1.26	0.66	2.04	1.22	0.74
LR Upper 95% CI	3.53	1.70	0.77	2.86	1.49	0.82