Journal of Hand Surgery Global Online 5 (2023) 804–809

Contents lists available at ScienceDirect

Journal of Hand Surgery Global Online

journal homepage: www.JHSGO.org

Original Research

Preoperative Anemia as a Risk Factor for Postoperative Complications After Open Reduction Internal Fixation of Distal Radius Fractures

Alexander R. Garcia, BS, [*] Kenny Ling, MD, [†] Samer Al-Humadi, MD, [†] David E. Komatsu, PhD, [†] Edward D. Wang, MD [†]

[*] Renaissance School of Medicine at Stony Brook University, Stony Brook, NY
[†] Department of Orthopaedics, Stony Brook University, Stony Brook, NY

A R T I C L E I N F O

Article history:
Received for publication April 11, 2023
Accepted in revised form July 15, 2023
Available online August 26, 2023

Key words:
Distal radius fracture
Open reduction internal fixation
Postoperative complication
Preoperative anemia

Purpose: The incidence of distal radius fractures (DRFs) in the United States is more than 640,000 cases per year and is projected to increase. The overall prevalence of anemia in the United States increased from 5.71% in 2005 to 6.86% in 2018. Therefore, preoperative anemia may be an important risk factor to consider before surgical fixation of a distal radius fracture. The purpose of this study was to investigate preoperative anemia and its association with short-term complications after surgical treatment of DRFs.
Methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried for all patients who underwent open reduction internal fixation (ORIF) of DRFs between 2015 and 2020. The initial pool of patients was divided into cohorts based on preoperative hematocrit. Multivariate logistic regression, adjusted for all significantly associated patient demographics and comorbidities, was used to identify associations between preoperative anemia and postoperative complications after ORIF of DRFs.
Results: A total of 22,923 patients who underwent ORIF of DRFs were identified in National Surgical Quality Improvement Program from 2015 to 2020. Of the 12,068 patients remaining after exclusion criteria, 9,616 (79.7%) patients were included in the normal cohort, 2,238 (18.5%) patients were included in the mild anemia cohort, and 214 (1.8%) patients were included in the severe anemia cohort. Compared with the reference cohort, patients with any anemia were independently associated with higher rates of reintubation (odds ratio [OR], 6.51; 95% confidence interval [CI], 1.29–32.80; $P = .023$), blood transfusion (OR, 11.83; 95% CI, 3.95–35.45; $P < .001$), septic shock (OR, 10.76; 95% CI, 1.19–97.02; $P = .034$), readmission (OR, 2.10; 95% CI, 1.60–2.76; $P < .001$), nonhome discharge (OR, 2.22; 95% CI, 1.84–2.68; $P < .001$), and mortality (OR, 2.70; 1.03–7.07; $P = .043$).
Conclusions: Preoperative anemia, both mild and severe, were clinically significant predictors for postoperative complications within 30-day after ORIF of DRFs. Severe anemia was associated with higher rates of blood transfusion, nonhome discharge, and mortality compared with mild anemia.
Type of study/level of evidence: Prognostic III.

Distal radius fractures (DRFs) are the most common upper-extremity fractures and account for approximately 25% of all upper-extremity fractures.[1,2] The incidence of DRFs in the United States is more than 640,000 cases per year and is projected to increase.[3,4] Surgical treatment of DRFs has increased as well due to advancements in technology. These advancements have improved the safety of surgical fixation of DRFs.[2,5,6]

Distal radius fractures most commonly occur in the pediatric and elderly populations.[7] A common mechanism of DRFs in the elderly is a fall onto an outstretched arm. A large portion of patients continue to be older and were women. A recent study that looked at the characteristics of patients who underwent distal radius open reduction and internal fixation (ORIF) between 2011 and 2020 found that the average age was 56 years old and 73% were woman.[2]

Declaration of interests: No benefits in any form have been received or will be received related directly to this article.

Corresponding author: Edward D. Wang, MD, Department of Orthopaedics, Stony Brook University Hospital, HSC T-18, Room 080, Stony Brook, NY 11794-8181.
E-mail address: Edward.Wang@stonybrookmedicine.edu (E.D. Wang).

https://doi.org/10.1016/j.jhsg.2023.07.013
2589-5141/

Older age and female sex have been reported to be associated with anemia.[8] The overall prevalence of anemia in the United States increased from 5.71% in 2005 to 6.86% in 2018.[8] Therefore, preoperative anemia may be an important risk factor to consider before surgical fixation of a DRF. Preoperative anemia has been found to be associated with stroke/cerebrovascular accident, postoperative anemia requiring transfusion, nonhome discharge, readmission, return to operating room, and renal complications.[9,10] Additionally, optimization of preoperative anemia has been shown to reduce cost and improve outcomes in total knee and hip arthroplasties.[11]

To our knowledge, preoperative anemia has not been studied in the setting of DRFs. The purpose of this study was to investigate preoperative anemia and its association with short-term complications after surgical treatment of DRFs. We hypothesized that preoperative anemia is associated with nonhome discharge.

Methods

The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database was queried for all patients who underwent ORIF of distal radius fracture between 2015 and 2020. The NSQIP database is fully deidentified, therefore rendering this study exempt from approval by our University's Institutional Review Board. Data in the NSQIP database are obtained from more than 600 hospitals in the United States and are collected by trained Surgical Clinical Reviewers.

Current Procedural Terminology codes 25607, 25608, and 25609 were used to identify patients who underwent ORIF of distal radius fracture from 2015 to 2020. Cases performed for trauma and for patients younger than 18 years of age were automatically excluded by the database. Cases were also excluded if any of the following variables has missing information: height/weight, American Society of Anesthesiologists (ASA) classification, discharge destination, functional health status before surgery, and preoperative hematocrit (Hct) level.

Variables collected in this study included patient demographics, comorbidities, preoperative laboratory values, surgical characteristics, and 30-day postoperative complication data. Patient demographics included age, body mass index, sex, functional health status before surgery, ASA classification, current smoking status, and chronic steroid use. Preoperative comorbidities included insulin- and noninsulin-dependent diabetes mellitus, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), hypertension, disseminated cancer, open wound/wound infection, and bleeding disorder. Preoperative laboratory values included hematocrit levels. Surgical characteristics included transfusion before surgery and operative duration. Postoperative complications that occurred within 30 days included pneumonia, superficial incisional surgical-site infection (SSI), deep incisional SSI, organ/space SSI, wound dehiscence, reintubation, pulmonary embolism, failure to wean off ventilator, urinary tract infection (UTI), stroke, cardiac arrest, myocardial infarction (MI), blood transfusion, deep vein thrombosis, sepsis, septic shock, readmission, reoperation, nonhome discharge, and mortality.

The initial pool of patients was divided into cohorts based on preoperative Hct: normal/reference (Hct $\geq$ 39 for men and Hct $\geq$ 36 for women), mild anemia (39 > Hct $\geq$ 29 for men and 36 > Hct $\geq$ 29 for women), and severe anemia (Hct < 29 for men and women). A cohort for any anemia in the analysis included both mild and severe anemia.

A total of 22,923 patients who underwent ORIF of DRFs were identified in NSQIP from 2015 to 2020. Cases were excluded as follows: 869 for missing height/weight, 23 for missing ASA classification, 15 for missing discharge destination, 374 for missing functional health status before surgery, and 9,575 for missing preoperative Hct. Of the 12,068 patients remaining after exclusion criteria, 9,616 (79.7%) patients were included in the normal cohort, 2,238 (18.5%) patients were included in the mild anemia cohort, and 214 (1.8%) patients were included in the severe anemia cohort.

All statistical analyses were conducted using SPSS Software version 29.0 (IBM Corp.). Patient demographics and comorbidities were compared between cohorts using bivariate logistic regression. Postoperative complications were also compared between cohorts using bivariate logistic regression.

Multivariate logistic regression, adjusted for all significantly associated patient demographics and comorbidities, was used to identify associations between preoperative anemia and postoperative complications after ORIF of DRFs. Odds ratio (OR) were reported with 95% confidence interval (CI). The level of statistical significance was set at $P < .05$.

Patients were further stratified into subgroups based on when their hematocrit laboratory value was obtained before surgery (same day, 1 day to 2 weeks before, and >2 weeks before). Multivariate logistic regression was used for these subgroups to further evaluate preoperative anemia and postoperative complications.

Results

Patient demographics and comorbidities were compared between cohorts, shown in Table 1. Compared with the reference cohort, the patient demographics and comorbidities significantly associated with any anemia were age $\geq$75 ($P < .001$), dependent functional status ($P < .001$), ASA $\geq$ 3 ($P < .001$), diabetes mellitus ($P < .001$), COPD ($P < .001$), CHF ($P < .001$), hypertension ($P < .001$), disseminated cancer ($P < .001$), open wound/wound infection ($P < .001$), chronic steroid use ($P < .001$), bleeding disorder ($P < .001$), transfusion before surgery ($P < .001$), and operative duration $\geq$ 94 minutes ($P = .002$). Compared with the reference cohort, the patient demographics and comorbidities significantly associated with mild anemia were age $\geq$75 ($P < .001$), body mass index < 18.5 ($P = .032$), dependent functional status ($P < .001$), ASA $\geq$ 3 ($P < .001$), noninsulin- and insulin-dependent diabetes mellitus ($P < .001$), COPD ($P < .001$), CHF ($P < .001$), hypertension ($P < .001$), disseminated cancer ($P < .001$), open wound/wound infection ($P < .001$), chronic steroid use ($P < .001$), bleeding disorder ($P < .001$), transfusion before surgery ($P = .011$), and operative duration $\geq$94 minutes ($P = 0.026$). Compared with mild anemia, the patient demographics and comorbidities significantly associated with severe anemia were female sex ($P = .012$), dependent functional status ($P < .001$), ASA $\geq$ 3 ($P <.001$), COPD ($P = .004$), CHF ($P = .011$), transfusion before surgery ($P < .001$), and operative duration $\geq$ 94 minutes ($P = .009$).

Postoperative complications that occurred within 30 days were compared between cohorts, shown in Table 2. Compared with the reference cohort, patients with any anemia had significantly higher rates of pneumonia ($P = 036$), reintubation ($P = 001$), UTI ($P = 005$), blood transfusion ($P < 001$), sepsis ($P = 010$), septic shock ($P = 007$), readmission ($P < 001$), nonhome discharge ($P < 001$), and mortality ($P < 001$). Compared with the reference cohort, patients with mild anemia had significantly higher rates of reintubation ($P = 005$), blood transfusion ($P < 001$), sepsis ($P = 021$), septic shock ($P = 011$), readmission ($P < 001$), nonhome discharge ($P < 001$), and mortality ($P = 019$). Compared with the mild anemia cohort, patients with severe anemia had significantly higher rates of UTI ($P = 036$), cardiac arrest ($P = 033$), blood transfusion ($P < 001$), nonhome discharge ($P < 001$), and mortality ($P < 001$).

After adjusting for the patient variables significantly associated with each anemia cohort, multivariate logistic regression identified the postoperative complications associated with preoperative anemia, shown in Table 3. Compared with the reference cohort, patients with any anemia were independently associated with

Table 1
Patient Demographics/Comorbidities in Patients With and Without Anemia Who Underwent Surgical Treatment of Distal Radius Fractures*

Characteristic	Normal		Any Anemia		Mild Anemia		Severe Anemia		Any vs No Anemia	Mild vs No Anemia	Severe vs Mild Anemia
	N	%	N	%	N	%	N	%	*P* Value	*P* Value	*P* Value
Total	9,616	100.0	2,452	100.0	2,238	100.0	214	100.0			
Age (y)									**<.001**	**<.001**	.966
18–39	1,179	12.3	204	8.3	192	8.6	12	5.6			
40–64	4,542	47.2	959	39.1	869	38.8	90	42.1			
65–74	2,405	25.0	648	26.4	598	26.7	50	23.4			
≥75	1,490	15.5	641	26.1	579	25.9	62	29.0			
Body mass index (kg/m^2)									.073	**.032**	.106
<18.5	211	2.2	94	3.8	79	3.5	15	7.0			
18.5–29.9	6,048	62.9	1,567	63.9	1,444	64.5	123	57.5			
30.0–34.9	1,880	19.6	447	18.2	403	18.0	44	20.6			
35.0–39.9	842	8.8	191	7.8	179	8.0	12	5.6			
≥40.0	635	6.6	153	6.2	133	5.9	20	9.3			
Gender									.211	.590	**.012**
Women	7,304	76.0	1,892	77.2	1,712	76.5	180	84.1			
Men	2,312	24.0	560	22.8	526	23.5	34	15.9			
Functional status									**<.001**	**<.001**	**<.001**
Independent	9,443	98.2	2,344	95.6	2,150	96.1	194	90.7			
Dependent	173	1.8	108	4.4	88	3.9	20	9.3			
ASA classification									**<.001**	**<.001**	**<.001**
1–2	6,482	67.4	1,154	47.1	1,084	48.4	70	32.7			
≥3	3,134	32.6	1,298	52.9	1,154	51.6	144	67.3			
Diabetes mellitus									**<.001**	**<.001**	.547
No	8,679	90.3	2,022	82.5	1,846	82.5	176	82.2			
Noninsulin	628	6.5	230	9.4	214	9.6	16	7.5			
Insulin	309	3.2	200	8.2	178	8.0	22	10.3			
Current smoker									.189	.081	.068
No	7,871	81.9	2,035	83.0	1,867	83.4	168	78.5			
Yes	1,745	18.1	417	17.0	371	16.6	46	21.5			
COPD									**<.001**	**<.001**	**.004**
No	9,228	96.0	2,258	92.1	2,072	92.6	186	86.9			
Yes	388	4.0	194	7.9	166	7.4	28	13.1			
Congestive heart failure									**<.001**	**<.001**	**.011**
No	9,585	99.7	2,420	98.7	2,213	98.9	207	96.7			
Yes	31	0.3	32	1.3	25	1.1	7	3.3			
Hypertension									**<.001**	**<.001**	.625
No	6,002	62.4	1,162	47.4	1,064	47.5	98	45.8			
Yes	3,614	37.6	1,290	52.6	1,174	52.5	116	54.2			
Disseminated cancer									**<.001**	**<.001**	.952
No	9,596	99.8	2,430	99.1	2,218	99.1	212	99.1			
Yes	20	0.2	22	0.9	20	0.9	2	0.9			
Open wound/wound infection									**<.001**	**<.001**	.167
No	9,410	97.9	2,348	95.8	2,147	95.9	201	93.9			
Yes	206	2.1	104	4.2	91	4.1	13	6.1			
Chronic steroid use									**<.001**	**<.001**	.509
No	9,357	97.3	2,338	95.4	2,132	95.3	206	96.3			
Yes	259	2.7	114	4.6	106	4.7	8	3.7			
Bleeding disorders									**<.001**	**<.001**	.091
No	9,380	97.5	2,300	93.8	2,105	94.1	195	91.1			
Yes	236	2.5	152	6.2	133	5.9	19	8.9			
Transfusion before surgery									**<.001**	**.011**	**<.001**
No	9,615	100.0	2,432	99.2	2,234	99.8	198	92.5			
Yes	1	0.0	20	0.8	4	0.2	16	7.5			
Operative duration (min)									**.002**	**.026**	**.009**
0–49	2,367	24.6	600	24.5	542	24.2	58	27.1			
50–93	4,951	51.5	1,195	48.7	1,109	49.6	86	40.2			
≥94	2,295	23.9	657	26.8	587	26.2	70	32.7			

* Bold *P* values indicate statistical significance with $P < .05$.

higher rates of reintubation (OR 6.51, 95% CI 1.29–32.80; $P = 023$), blood transfusion (OR, 11.83; 95% CI, 3.95–35.45; $P < 001$), septic shock (OR, 10.76; 95% CI, 1.19–97.02; $P = 034$), readmission (OR, 2.10; 95% CI, 1.60–2.76; $P < 001$), nonhome discharge (OR, 2.22; 95% CI, 1.84–2.68; $P < 001$), and mortality (OR, 2.70; 1.03–7.07; $P = 043$). Compared with the reference cohort, patients with mild anemia were independently associated with higher rates of reintubation (OR, 5.71; 95% CI, 1.05–31.07; $P = 044$), blood transfusion (OR, 7.03; 95% CI, 2.16–22.90; $P = 0001$), septic shock (OR, 9.57; 95% CI, 1.01–90.93; $P = 049$), readmission (OR, 2.05; 95% CI, 1.55–2.73; $P < 001$), and nonhome discharge (OR, 2.04; 95% CI, 1.67–2.49; $P < 001$). Compared with the mild anemia cohort, patients with severe anemia were independently associated with higher rates of blood transfusion (OR, 7.91; 95% CI, 3.29–19.03; $P < 001$), nonhome discharge (OR, 2.04; 95% CI, 1.40–2.97; $P < 001$), and mortality (OR, 7.02; 95% CI, 2.05–24.08; $P = 002$).

Table 2
Bivariate Analysis of 30-Day Postoperative Complications in Patients With No Anemia, Mild Anemia, and Severe Anemia*

Complication	Normal (n = 9,616)		Any Anemia (n = 2,452)		Mild Anemia (n = 2,238)		Severe Anemia (n = 214)		Any vs No Anemia	Mild vs No Anemia	Severe vs Mild Anemia
	N	%	N	%	N	%	N	%	*P* Value	*P* Value	*P* Value
Pneumonia	5	0.05	3	0.12	2	0.09	1	0.47	**.036**	.100	.223
Superficial incisional SSI	28	0.29	11	0.45	10	0.45	1	0.47	.224	.244	.966
Deep incisional SSI	5	0.05	3	0.12	2	0.09	1	0.47	.241	.517	.177
Organ/space SSI	5	0.05	2	0.08	2	0.09	0	0.00	.590	.517	.999
Wound dehiscence	5	0.05	0	0.00	0	0.00	0	0.00	.999	.999	—
Reintubation	2	0.02	7	0.29	5	0.22	2	0.93	**.001**	**.005**	.087
Pulmonary embolism	7	0.07	3	0.12	3	0.13	0	0.00	.452	.376	.999
Ventilator >48 h	0	0.00	4	0.16	3	0.13	1	0.47	—	—	.279
Urinary tract infection	36	0.37	21	0.86	16	0.71	5	2.34	**.005**	.057	**.036**
Stroke	5	0.05	1	0.04	1	0.04	0	0.00	.824	.890	.999
Cardiac arrest	0	0.00	5	0.20	3	0.13	2	0.93	—	—	**.033**
MI	9	0.09	3	0.12	3	0.13	0	0.00	.688	.590	.999
Blood transfusions	4	0.04	26	1.06	11	0.49	15	7.01	**<.001**	**<.001**	**<.001**
Deep vein thrombosis	8	0.08	3	0.12	2	0.09	1	0.47	.569	.928	.177
Sepsis	5	0.05	6	0.24	5	0.22	1	0.47	**.010**	**.021**	.500
Septic shock	1	0.01	5	0.20	4	0.18	1	0.47	**.007**	**.011**	.390
Readmission	137	1.42	104	4.24	91	4.07	13	6.07	**<.001**	**<.001**	.167
Reoperation	99	1.03	30	1.22	27	1.21	3	1.40	.405	.463	.804
Nonhome discharge	265	2.76	244	9.95	199	8.89	45	21.03	**<.001**	**<.001**	**<.001**
Mortality	7	0.07	11	0.45	6	0.27	5	2.34	**<.001**	**.019**	**<.001**

* Bold *P* values indicate statistical significance with $P < .05$.

Table 3
Multivariate Analysis of 30-Day Postoperative Complications in Patients With Preoperative Anemia, Adjusted for Significantly Associated Patient Demographics and Comorbidities*

Complication	Any vs No Anemia			Mild vs No Anemia			Severe vs Mild Anemia		
	OR	95% CI	*P* Value	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Pneumonia	1.35	0.60–3.03	.463	—	—	—	—	—	—
Reintubation	6.51	1.29–32.80	**.023**	5.71	1.05–31.07	**.044**	—	—	—
UTI	1.48	0.85–2.57	.168	—	—	—	2.02	0.73–5.62	.177
Cardiac arrest	—	—	—	—	—	—	4.12	0.66–25.68	.130
Blood transfusions	11.83	3.95–35.45	**<.001**	7.03	2.16–22.90	**.001**	7.91	3.29–19.03	**<.001**
Sepsis	2.63	0.72–9.69	.145	3.06	0.83–11.27	.093	—	—	—
Septic shock	10.76	1.19–97.02	**.034**	9.57	1.01–90.93	**.049**	—	—	—
Readmission	2.10	1.60–2.76	**<.001**	2.05	1.55–2.73	**<.001**	—	—	—
Nonhome discharge	2.22	1.84–2.68	**<.001**	2.04	1.67–2.49	**<.001**	2.04	1.40–2.97	**<.001**
Mortality	2.70	1.03–7.07	**.043**	1.72	0.57–5.17	.335	7.02	2.05–24.08	**.002**

* Bold *P* values indicate statistical significance with $P < .05$.

Table 4
Days From Preoperative Hematocrit Value to Procedure

Time Before Surgery	No Anemia	Mild Anemia	Severe Anemia
Same day	2,155	748	109
1 d to 2 wk	6,213	1,256	83
>2 wk	1,248	234	22

Patients were further stratified into subgroups based on when their preoperative hematocrit laboratory value was obtained before surgery (Table 4). Multivariate logistic regression was again used to identify associations between anemia and postoperative complications within these groups (Table 5). Patients with anemia, identified from laboratories obtained within 2 weeks before their surgery, were independently associated with higher rates of blood transfusion, readmission, and nonhome discharge. Anemia identified > 2 weeks before surgery was not found to be associated with higher rates of complications.

Discussion

In our analysis of more than 12,000 patients undergoing distal radius ORIF, we found that comorbidities significantly associated with preoperative anemia were age ≥ 75 years, dependent functional status, ASA ≥ 3, diabetes mellitus, COPD, CHF, hypertension, disseminated cancer, open wound/wound infection, chronic steroid use, bleeding disorder, transfusion before surgery, and operative duration ≥ 94 minutes. This study found that preoperative anemia was associated with many postoperative complications within 30 days of DRF repair, including nonhome discharge, mortality, septic shock, reintubation, blood transfusions, and readmission after adjusting for patient variables. Interestingly, we found that patients with even mild anemia were at a greater risk for reintubation, blood transfusions, septic shock, readmission, and nonhome discharge. In addition, severe anemia compared with mild anemia was an independent risk factor for blood transfusions, nonhome discharge, and mortality.

A study by Herrick et al[12] identified associations between preoperative anemia and mortality in patients undergoing primary total joint arthroplasty (TJA). This study spanned 4 years. However, Greenky et al[13] and Kashanchi et al[10] studied patients with preoperative anemia undergoing TJA and total shoulder arthroplasty, respectively, and did not find associations with mortality. This could have been due to the fact that they only looked at 30-day postoperative outcomes.

Table 5
Multivariate Analysis of 30-Day Postoperative Complications in Patients With Preoperative Anemia, Stratified by the Time Between Hematocrit Value Was Determined Before Surgery*

Complication	Any Anemia (Laboratory Same Day)			Any Anemia (Laboratory 1 d to 2 wk)			Any Anemia (Laboratory >2 wk)		
	OR	95% CI	*P* Value	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Reintubation	—	—	—	3.71	0.58–23.82	.167	—	—	—
Blood transfusions	22.05	2.84–171.40	**.003**	5.00	1.14–21.83	**.033**	—	—	—
Septic shock	—	—	—	5.52	0.45–67.11	.180	—	—	—
Readmission	2.35	1.44–3.84	< **.001**	1.86	1.28–2.68	**.001**	1.77	0.74–4.20	.199
Nonhome discharge	2.95	2.21–3.95	< **.001**	1.36	1.01–1.82	**.040**	2.21	0.97–5.04	.060
Mortality	—	—	—	1.42	0.31–6.57	.655	—	—	—

* Bold *P* values indicate statistical significance with $P < .05$.

Other investigations studying TJA cohorts have found associations with complications similar to Greenky and Kashanchi, such as increased length of stay, prosthetic joint infection, and nonhome discharge. These studies have also found that severe anemia results in more postoperative complications when compared with mild anemia.[10,12–15] The association between DRFs and other fragility fractures in the elderly may explain the increased mortality in an already frail and elderly population.[16–18]

Anemia is a treatable condition that can readily detected before surgery.[19] A study by Wan et al[11] investigated the budget impact of treating preoperative anemia in orthopedic patients in Sweden. There, the preoperative anemic rate of 21.5% was similar to our cohort of 19.3%. They ran a cost simulation model to simulate the total cost of testing patients for underlying causes of anemia and treating them for optimization before surgery. The investigation demonstrated that treatment of all anemic patients before orthopedic procedures would improve outcomes and save on costs.[11] However, it is important to consider that Wan et al investigated anemia in the setting of total knee and hip arthroplasties. The elective nature of these procedures allows for patients to be seen and managed before surgery by nutritionists and other specialists. These patients can therefore be medically optimized with iron supplementation or other treatments to improve their anemia. In the setting of a nonelective DRF, the time available for a multidisciplinary approach to address anemia is much more limited.

A study by Shapiro et al[4] reported that there was strong evidence that showed patients older than the age of 65 years did not benefit long term from operative versus nonsurgical treatment of DRFs. However, other studies have reported that conservative treatment efforts can result in repeated loss of reduction, making ORIF necessary in active elderly patients.[17,20–22] The 2020 clinical practice guidelines state that patients older than 65 years of age should be treated nonoperatively whenever possible.[4] A large portion of our anemic population was older than the age of 75 years, well past the recommendation for operative treatment of a DRF. In our cohort, patients older than the age of 65 years accounted for more than half of the patients observed with either mild or severe anemia. Our analysis of postoperative complications seen in patients stratified by anemia severity is consistent with previous studies. Our findings may support the recommendation that elderly patients can be poor candidates for ORIF of DRFs.

Our study is unique in its stratification of preoperative anemia by severity in patients undergoing distal radius ORIF. We attempted to further investigate the effect of anemia by looking at the proximity to surgery during which the hematocrit laboratory values were determined. Our investigation is not without limitations. A major limitation is that NSQIP inherently excludes cases performed for trauma, which likely excludes cases of DRF ORIF in polytrauma patients. Although this does not allow us to investigate a certain portion of DRF cases, it may be beneficial to our analysis because anemia is much more difficult to control in a polytrauma setting. The NSQIP database only allows us to investigate postoperative complications within 30 days of the procedure. Of note, the postoperative data include medical complications but do not include fracture-specific outcomes that would be of interest from a surgical perspective, such as malunion, nonunion, infection, hardware failure, and poor function. In addition, the underlying etiology of patients' anemia cannot be analyzed with the NSQIP database. Therefore, we also cannot determine whether any attempts were made at the preoperative treatment of anemia other than transfusion before surgery. Our further analysis into when hematocrit laboratory values were obtained before surgery was limited by the data only showing the days between the most recent laboratory value and the surgery. Any laboratory values obtained before the most recent one were not available, therefore limiting our ability to determine the acuity or chronicity of the identified anemia.

Despite these limitations, we used a national surgical database to analyze a large cohort of patients with preoperative anemia to evaluate the risk of complications after ORIF of DRFs. Further studies should investigate the effects of before surgery treating the underlying causes of anemia in patients to determine its effect on postoperative complications and outcomes. Considering that many causes of anemia are chronic in nature, treatment may take more than 30 days to be effective, especially given that anemia due to acute blood loss related to DRF is less likely. Therefore, a prospectively enrolled study that before surgery assesses for anemia levels and their cause, addresses the anemia with the appropriate referrals for preoperative optimization, and has a longer postoperative follow-up to assess complications would help to determine the effects of treating anemia before surgery. A longer follow-up period of 1 year would allow for the proper assessment of postoperative complications including fracture-specific outcomes.

References

1. Corsino CB, Reeves RA, Sieg RN. *Distal Radius Fractures*. StatPearls; 2022.
2. Zhang D, Dyer GSM, Earp BE, Blazar P. Ten-year national trends in patient characteristics and 30-day outcomes of distal radius fracture open reduction and internal fixation. *J Am Acad Orthop Surg Glob Res Rev*. 2022;6(9):e22.00181.
3. Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. *J Hand Surg Am*. 2001;26(5):908–915.
4. Shapiro LM, Kamal RN. Management of Distal Radius Fractures Work G, et al. Distal radius fracture clinical practice guidelines-updates and clinical implications. *J Hand Surg Am*. 2021;46(9):807–811.
5. Del Pinal F, Jupiter JB, Rozental TD, Arora R, Nakamura T, Bain GI. Distal radius fractures. *J Hand Surg Eur*. 2022;47(1):12–23.
6. Koval KJ, Harrast JJ, Anglen JO, Weinstein JN. Fractures of the distal part of the radius. The evolution of practice over time. Where's the evidence? *J Bone Joint Surg Am*. 2008;90(9):1855–1861.
7. Azad A, Kang HP, Alluri RK, Vakhshori V, Kay HF, Ghiassi A. Epidemiological and treatment trends of distal radius fractures across multiple age groups. *J Wrist Surg*. 2019;8(4):305–311.
8. Wang C, Wang Y. Trends in prevalence and treatment rate of anemia in the U.S. population: cross-sectional study using data from NHANES 2005-2018. *Hematology*. 2022;27(1):881–888.

9. Fowler AJ, Ahmad T, Phull MK, Allard S, Gillies MA, Pearse RM. Meta-analysis of the association between preoperative anaemia and mortality after surgery. *Br J Surg*. 2015;102(11):1314–1324.
10. Kashanchi KI, Nazemi AK, Komatsu DE, Wang ED. The impact of preoperative anemia on complications after total shoulder arthroplasty. *J Am Acad Orthop Surg Glob Res Rev*. 2021;5(1):e20.00136.
11. Wan S, Sparring V, Cabrales DA, Jansson KA, Wikman A. Clinical and budget impact of treating preoperative anemia in major orthopedic surgery-A retrospective observational study. *J Arthroplasty*. 2020;35(11):3084–3088.
12. Herrick MD, Sites BD, Masaracchia MM, Moschetti W. Preoperative anemia is associated with increased mortality following primary unilateral total joint arthroplasty. *Open J Anesthesiol*. 2016;06:91–96.
13. Greenky M, Gandhi K, Pulido L, Restrepo C, Parvizi J. Preoperative anemia in total joint arthroplasty: is it associated with periprosthetic joint infection? *Clin Orthop Relat Res*. 2012;470(10):2695–2701.
14. Frangie R, Masrouha KZ, Abi-Melhem R, Tamim H, Al-Taki M. The association of anaemia and its severity with composite morbidity after total hip arthroplasty. *Hip Int*. 2021;31(2):201–206.
15. Gu A, Malahias MA, Selemon NA, et al. Increased severity of anaemia is associated with 30-day complications following total joint replacement. *Bone Joint J*. 2020;102-B(4):485–494.
16. Barrett-Connor E, Sajjan SG, Siris ES, Miller PD, Chen YT, Markson LE. Wrist fracture as a predictor of future fractures in younger versus older postmenopausal women: results from the National Osteoporosis Risk Assessment (NORA). *Osteoporos Int*. 2008;19(5):607–613.
17. Mauck BM, Swigler CW. Evidence-based review of distal radius fractures. *Orthop Clin North Am*. 2018;49(2):211–222.
18. Schousboe JT, Fink HA, Taylor BC, et al. Association between self-reported prior wrist fractures and risk of subsequent hip and radiographic vertebral fractures in older women: a prospective study. *J Bone Miner Res*. 2005;20(1):100–106.
19. Bisbe E, Basora M, Colomina MJ. Spanish Best Practice in Peri-operative Anaemia Optimisation P. Peri-operative treatment of anaemia in major orthopaedic surgery: a practical approach from Spain. *Blood Transfus*. 2017;15(4):296–306.
20. Leone J, Bhandari M, Adili A, McKenzie S, Moro JK, Dunlop RB. Predictors of early and late instability following conservative treatment of extra-articular distal radius fractures. *Arch Orthop Trauma Surg*. 2004;124(1):38–41.
21. Nesbitt KS, Failla JM, Les C. Assessment of instability factors in adult distal radius fractures. *J Hand Surg Am*. 2004;29(6):1128–1138.
22. Porter M, Stockley I. Fractures of the distal radius. Intermediate and end results in relation to radiologic parameters. *Clin Orthop Relat Res*. 1987;220:241–252.