Preoperative Risk Factor Score Predicts Malnutrition in Total Joint Arthroplasty Patients

Sarah Rudasill[1]
Daniel Gittings, MD[2]
Nabil Elkassabany, MD[3]
Jiabin Liu, M.D, PhD[3]
Charles Nelson, MD[4]
Atul Kamath, MD[4]

[1]Research Specialist
3737 Market Street, 6th Floor
Philadelphia, PA 19104

[2]Resident, Orthopaedic Surgery
University of Pennsylvania
3737 Market Street, 6th Floor
Philadelphia, PA 19104

[3]Attending Anesthesiologist
University of Pennsylvania
3400 Spruce Street, 6 Dulles Building
Philadelphia, PA 19104

[4]Attending Orthopaedic Surgeon
University of Pennsylvania
Department of Orthopaedic Surgery
800 Spruce Street
Philadelphia, PA 19107

Introduction

Malnutrition is a modifiable risk factor associated with greater risk of perioperative complications and hospital lengths of stay in patients undergoing total hip arthroplasty (THA) and total knee arthroplasty (TKA)[1,4,3,11]. Previous literature has identified hypoalbuminemia (serum albumin < 3.5 g/dL) as a reliable measure for malnutrition[2,6,7,10]. Preoperative diagnosis of hypoalbuminemia allows intervention with evidenced-based nutrition regimens that may correct malnutrition prior to joint arthroplasty and improve outcomes[2,5]. While advanced age, male gender, emergency cases, and high American Society of Anesthesiologists (ASA) physical status classifications have been previously associated with malnutrition, identification of patients at-risk for hypoalbuminemia has proven difficult[4,8,9]. The purpose of this study is to examine risk factors for hypoalbuminemia and develop a predictive model that identifies at-risk patients prior to elective total joint arthroplasty.

Methods

We retrospectively reviewed the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database from 2006 to 2014 to analyze preoperative independent risk factors for a diagnosis of hypoalbuminemia in adult patients with Current Procedural Terminology (CPT) codes for primary THA (CPT 2130) and primary TKA (CPT 27447). Missing serum albumin levels, emergent cases, or ASA $\geq$ 4 were excluded. Multivariate regression analysis was used to evaluate the impact of independent risk factors, including age, sex, race, date of operation, surgery within the past thirty days, tobacco use, alcohol consumption, functional status, dyspnea at rest or with moderate exercise, chronic obstructive pulmonary disease (COPD), diabetes mellitus (DM) type I and II, liver disease, congestive heart failure (CHF), coronary artery disease (CAD), hypertension necessitating medications, peripheral vascular disease, renal failure, central nervous system disease, spinal cord injury, and chronic steroid use.

THA and TKA were analyzed separately. Significant risk factors were used to develop a seven-point preoperative risk model to predict hypoalbuminemia in joint arthroplasty patients. Continuous variables were analyzed via t-test, categorical variables were analyzed with Fisher's exact test and chi-square test, and predictive validity was assessed by comparing hypoalbuminemia diagnosis to a calculated hypoalbuminemia risk score.

Results

There were 35,837 complete THA records and 56,008 complete TKA records. Among THA patients, 1,684 (4.7%) had hypoalbuminemia and 34,153 (95.3%) did not. Among TKA patients, 2,327 (4.15%) had hypoalbuminemia and 53,681 (95.85%) did not. According to Table 1, seven factors emerged as significant, independent predictors of hypoalbuminemia prior to both hip and knee arthroplasty: age, sex, surgery within the prior 30 days, diabetes mellitus (DM) type I, liver disease, central nervous system disease, and chronic steroid use. Poor functional status and tobacco use were unique independent risk factors for malnutrition in THA patients, while ethnic race and dyspnea at rest were unique factors in TKA patients.

The proposed model is a seven-point scale, with one point assigned to each shared risk factor for hypoalbuminemia (Table 2). A score of three or greater indicates a high pre-test probability of hypoalbuminemia. According to Table 3, 1.7% of the THA cohort (608 patients) and 2.0% of the TKA cohort (1,138 patients) were identified as at-risk for hypoalbuminemia. The positive predictive value for THA patients scoring three or greater was 20.4%, while the negative predictive value for scoring below three was 95.6%. For TKA, the positive predictive value for patients scoring three or greater was 10.54%, while the negative predictive value for below three was 96.0%.

Discussion

The purpose of this study was to identify risk factors for hypoalbuminemia in THA and TKA patients and develop a model that preoperatively predicts malnutrition. Since hypoalbuminemia is associated with a higher risk of complications following joint arthroplasty, a targeted, cost-effective screening method for hypoalbuminemic patients may improve outcomes through more extensive preoperative nutrition management[2,5,6,7,10].

Table 1. Identification of risk factors that predict hypoalbuminemia in patients undergoing THA and TKA.

	THA (27130)			TKA (27447)		
Risk Factor	**Odds Ratio**	**95% Confidence Interval**	**P-value**	**Odds Ratio**	**95% Confidence Interval**	**P-value**
Age						
60-69 years	1.10	0.77 - 1.58	0.591	0.94	0.73 - 1.20	0.601
70-79 years	1.42	0.98 - 2.07	0.067	1.05	0.81 - 1.37	0.685
≥ 80 years	1.87	1.22 - 2.87	0.004	1.76	1.30 - 2.37	<0.001
Female	1.41	1.07 - 1.85	0.014	1.29	1.06 - 1.58	0.010
Race						
Black	1.27	0.81 - 1.97	0.296	1.40	1.04 - 1.88	0.027
Hispanic	0.51	0.24 - 1.11	0.090	1.05	0.77 - 1.41	0.767
Asian, Pacific Islander, and Other	1.75	0.65 - 4.72	0.271	1.06	0.59 - 1.93	0.837
Year of Operation	1.09	0.99 - 1.21	0.091	1.01	0.95 - 1.08	0.708
Diabetes						
Type II	0.80	0.51 - 1.26	0.337	1.11	0.87 - 1.43	0.394
Type I	3.12	1.95 - 5.00	<0.001	2.31	1.69 - 3.16	<0.001
Dyspnea						
At rest	1.36	0.89 - 2.06	0.151	1.56	1.21 - 2.00	0.001
Moderate exertion	2.02	0.58 - 6.98	0.267	0.44	0.06 - 3.25	0.420
Functional status	3.51	2.61 - 4.74	<0.001	1.22	0.86 - 1.75	0.262
Smoking status	1.77	1.26 - 2.49	0.001	1.20	0.88 - 1.63	0.253
Alcohol consumption	0.51	0.22 - 1.19	0.119	1.57	0.90 - 2.76	0.114
COPD Diagnosis	1.52	0.94 - 2.44	0.085	1.44	0.99 - 2.08	0.056
Liver disease	23.38	2.93 - 186.49	0.003	7.77	1.11 - 54.60	0.039
Congestive heart failure	2.13	0.47 - 9.61	0.325	2.58	0.55 - 12.08	0.230
Coronary artery disease	0.94	0.62 - 1.43	0.772	0.81	0.60 - 1.10	0.179
Hypertension	1.18	0.88 - 1.57	0.273	1.17	0.95 - 1.45	0.144
Peripheral vascular disease	0.90	0.26 - 3.13	0.874	0.60	0.18 - 1.98	0.401
Renal failure	1.50	0.36 - 6.21	0.579	2.86	0.92 - 8.88	0.070
Central nervous system disease	2.55	1.74 - 3.76	<0.001	1.47	1.07 - 2.03	0.019
Spinal cord injury		omitted		0.31	0.04 - 2.37	0.261
Chronic steroid use	2.00	1.27 - 3.16		2.50	1.76 - 3.57	<0.001
Surgery within past 30 days	15.59	5.23 - 46.44		3.36	1.32 - 8.52	0.011
_constant	1.61e-80	7.40e-171 to 3.48e10		2.41e-13	8.19e-71 - 7.12e44	0.667

There were seven significant, independent predictors of hypoalbuminemia prior to hip and knee arthroplasty: age, sex, surgery within the prior 30 days, diabetes mellitus (DM) type I, liver disease, central nervous system disease, and chronic steroid use. Advanced age as a risk factor for malnutrition is consistent with previously published literature[4,8]. However, our analysis found that females are more likely to be malnourished for both THA (OR 1.41, p = 0.014, CI 1.07-1.85) and TKA (OR 1.29, p = 0.010, CI 1.06 − 1.58), differing from a previous report that found male sex as a risk factor for hypoalbuminemia[8]. The previous report included emergent cases in their analysis, so the discrepancy may result from our focus on elective primary arthroplasty patients.

The seven-point model in Table 2 is useful for clinical decision making in patients undergoing both THA and TKA. One in five of the model's designated high-risk THA patients, and one in ten of the model's designated high-risk TKA patients, had hypoalbuminemia. Previous studies have found that the incidence of malnutrition in patients undergoing THA or TKA was 8.5%[4]. In this study, only 4.70% of THA patients and 4.15% of TKA had hypoalbuminemia. This quick scoring mechanism thus identifies THA patients with nearly five times the risk, and TKA patients with double the risk, of hypoalbuminemia relative to all patients undergoing procedures.

We were limited by a retrospective study design and the small proportion of patients scoring three or greater in the model. A majority of patients using this model remain false positives, but optimization of the model could reduce large standard errors and permit weighting of risk factors to improve accuracy. Future research should attempt to weight factors, incorporate a larger patient population, and focus on improving predictions prior to TKA, for which predictions are half as accurate as THA.

Conclusion

Efforts to identify joint arthroplasty patients at risk for hypoalbuminemia resulted in a model that predicts prevalence above rates of malnutrition observed in the general population. Accurate identification of hypoalbuminemic patients may allow preoperative nutrition interventions to improve postoperative outcomes and to serve as a framework for prospective studies on malnutrition optimization pre-operatively.

Table 2. Predictive model for hypoalbuminemia

Seven-Point Model		THA		TKA	
Factor	**Points**	**Odds Ratio**	**Standard Error**	**Odds Ratio**	**Standard Error**
Age ≥ 80 years	1	1.87	0.41	1.76	0.27
Female	1	1.41	0.20	1.29	0.13
Diabetes Mellitus Type I	1	3.12	0.75	2.31	0.37
Liver disease	1	23.38	24.77	7.77	7.73
Central nervous system disease	1	2.55	0.50	1.47	0.24
Chronic steroid use	1	2.00	0.47	2.50	0.45
Surgery within past 30 days	1	15.59	8.68	3.36	1.60

Table 3. Model's predictive value for hypoalbuminemia prior to THA and TKA

	THA			TKA		
Albumin Risk Score	**Normal Albumin**	**Hypo-albuminemia**	**Total**	**Normal Albumin**	**Hypo-albuminemia**	**Total**
0	97.41%	2.59%	13,295 (37.1%)	97.56%	2.44%	16,717 (29.8%)
1	95.57%	4.43%	17626 (49.2%)	96.01%	3.99%	30,627 (54.7%)
2	89.90%	10.10%	4,308 (12.0%)	92.69%	7.31%	8,072 (14.4%)
3	80.94%	19.06%	551 (1.5%)	89.86%	10.14%	1,065 (1.9%)
4	66.07%	33.93%	56 (0.15%)	84.72%	15.28%	72 (0.13%)
5	100%	0%	1 (0%)	0%	100%	1 (0%)
Total	34,153 (95.30%)	1,684 (4.70%)	35,837 (100%)	53,681 (95.8%)	2,327 (4.2%)	56,008 (100%)
+ Predictive Value (≥3)		20.4%			10.5%	
- Predictive Value (≥3)		95.6%			96.0%	

References

1. Bohl DD, Shen MR, Kayupov E, Della Valle CJ. Hypoalbuminemia Independently Predicts Surgical Site Infection, Pneumonia, Length of Stay, and Readmission After Total Joint Arthroplasty. *J Arthroplasty.* 2016 Jan; 31(1):15-21.

2. Cross MB, Yi PH, Thomas CF, Garcia J, Della Valle CJ. Evaluation of malnutrition in orthopaedic surgery. *J Am Acad Orthop Surg.* 2014;22:193–199.

3. Del Savio GC, Zelicof SB, Wexler LM, Byrne DW, Reddy PD, Fish D, Ende KA. Preoperative nutritional status and outcome of elective total hip replacement. *Clin Orthop Relat Res.* 1996 May; (326):153-61.

4. Huang R, Greenky M, Kerr GJ, Austin MS, Parvizi J. The effect of malnutrition on patients undergoing elective joint arthroplasty. *J Arthroplasty.* 2013;28(8):21–24.

5. Jensen JE, Jensen TG, Smith TK, Johnston DA, Dudrick SJ. Nutrition in Orthopaedic Surgery. *J Bone Joint Surg Am.* 1982;64(9):1263-272.

6. Nelson CL, Elkassabany NM, Guo Z, Liu J, Kamath AF. Low Albumin Is a Risk Factor for Complications after Revision Total Knee Arthroplasty. *J Knee Surg.* 2016;ePub ahead of print.

7. Nelson CL, Elkassabany NM, Kamath AF, Liu J. Low Albumin Levels, More Than Morbid Obesity, Are Associated With Complications After TKA. *Clin Orthop Relat Res.* 2015;473(10):3163-172.

8. Nicholson JA, Dowrick AS, Liew SM. Nutritional status and short-term outcome of hip arthroplasty. *J Orthop Surg (Hong Kong).* 2012;20:331–335.

9. Ozkalkanli MY, Ozkalkanli DT, Katircioglu K, Savaci S. Comparison of tools for nutrition assessment and screening for predicting the development of complications in orthopedic surgery. *Nutr Clin Pract.* 2009;24(2):274–280.

10. Walls JD, Abraham D, Nelson CL, Kamath AF, Elkassabany NM, Liu J. Hypoalbuminemia More Than Morbid Obesity is an Independent Predictor of Complications After Total Hip Arthroplasty. *J Arthroplasty.* 2015 Dec;30(12):2290-5

11. Yi PH, Frank RM, Vann E, Sonn KA, Moric M, Della Valle CJ. Is potential malnutrition associated with septic failure and acute infection after revision total joint arthroplasty? *Clin Orthop Relat Res.* 2015;473:175–182.